

The Blast Furnace and Steel Plant

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High Quality Steel

EVER since the first pound of steel was made there has been an effort, although at times very feeble, to improve both the metal and the means of making it. Some of these improvements have given us a metal enhanced in quality while others have increased the quantity produced in a unit of time. For many years attention was directed mostly to this latter phase of steel manufacture; but as specifications, especially from the makers of automobiles, assumed more stringent forms and rejections became more numerous the production of higher quality steels was not only advisable, it was imperative. With passing years this situation has been accentuated until today practically every steel company has established a research department for the purpose of discovering a means whereby the quality of its steel may be raised.

Usually investigation has been retrogressive in form. That is, the start has been with the finished steel and has passed back through the rolling mills to the open hearth; then to the blast furnace, and finally to the "raw" products—coal, ore and stone. At present research is all inclusive in that every process is subjected to the closest scrutiny, consequently steel making is now conducted along more scientific lines than ever before. Variables still exist and undoubtedly some, from the nature of the materials and methods employed, always will exist, but their number is less than heretofore and will decrease as science reveals their presence and means are made available for their elimination.

Individual efforts, or the efforts of isolated organizations, can make some advancement towards improving quality, but the combined efforts of the steel industry as a whole is of tremendous import. It is this combined action that promises much. The spirit of co-operation that has been evidenced at the various meetings of steel plant engineers and executives this Spring augurs well for the spread of information that will be helpful to all.

Methods of Cleaning Blast-Furnace Gas*

A Comparison of Twelve Important Installations Using Various Methods—Results Tabulated to Show the Performance and the Operating Costs as Well

By V. HARBORD†

THE efficient cleaning of blast-furnace gas is one of the many problems which have confronted the manufacturers of iron and steel for many years, as only by this means can full benefits be obtained from this source of fuel. The large amount of gas evolved from the blast-furnace plant has been one of the main difficulties met with in the design of cleaning plants, but there are at the present day several very satisfactory cleaners working, whereby enormous direct savings are being made in the actual use of coal throughout the works, and indirect savings in repairs to hot blast stoves, boiler cleaning, and general efficiency in the plant.

Although results obtained from individual plants have been published, so far as the author is aware no independent detailed works results over a reasonable period of a number of plants are available, from which a comparison of the relative efficiencies of different types of plants can be made. It was thought that actual operating figures would be of interest, and with the consent of the directors and the co-operation and assistance of the staffs of a number of works in England, the actual works records have been placed at the disposal of the author, the information given as to the general results thus obtained being embodied in this paper.

Gas-cleaning plants may be conveniently classified in two main classes—dry cleaners and wet cleaners—and the former can be further subdivided into those which filter the gas and those which remove the dust from the gas by electrical precipitation.

The best-known dry cleaners of the filtration type are the Halberg-Beth and the Kling Weidlein wire mattress cleaner, while the Lodge-Cottrell is the only type of electrostatic cleaner which has established itself in England.

The wet-cleaning plants at work in England are frequently of composite design, but they all depend essentially on getting an intimate mixture between a fine spray or mist of water and the gas, either by means of spraying or scrubbing in towers or by fan disintegrators of the Theisen type, or by a combination of both.

Another distinction which is frequently made between types of gas cleaners is between those which are capable of treating the gas hot and thus preserving the sensible heat, and those which necessitate cooling the gas prior to cleaning; of the former the electrostatic and the Kling Weidlein are the most important examples, and considerable importance is attached by the patentees or manufacturers to this saving in sensible heat. This advantage is not so great as may appear at first sight, as the gases at the higher temperature are capable of carrying a larger amount of water vapor, which will retard combustion. By cooling the gases below their dew point, water will to a certain

extent be removed, and the loss of sensible heat will be partly balanced by obtaining a drier gas for combustion, notwithstanding the intimate contact with the water during cleaning.

There are great difficulties in comparing the results obtained by the various types of cleaners, as few types are designed to clean down to the same extent, nor are the conditions under which each is operating similar in all cases. The quantity, quality, and fineness of the dust all have a considerable bearing on the question, as it is obviously an easier matter to remove the coarser particles than the extremely fine material, and the variation in the dust from the same furnace from hour to hour makes it extremely difficult to generalize. Again, it is manifestly unfair to compare the relative cleaning efficiency of a Kling Weidlein apparatus with that of the Halberg-Beth, as the former is only claimed to act as a primary cleaner.

With certain types of cleaners—more especially those of the wet type—a certain amount of latitude is possible in this respect by regulating the amount of water used, and it is a matter for the management to decide at which point the benefits obtained from additional cleaning become no longer economical.

When comparing the results obtained from different types of cleaners, the dust content of the final gas is the most suitable basis of comparison, bearing in mind, of course, whether the apparatus is designed as a primary or a final cleaner. Somewhat misleading figures are sometimes given under the name of "efficiency," as expressed in the percentage of the dust extracted; almost any type of dust-catcher will extract coarse dust, and the efficiency so defined will depend almost entirely on the relative coarseness and the quantity of the dust in the crude gas. With a dirty gas a good "efficiency" can thus be shown, although the resulting cleaned gas may still contain a large amount of dust. The desired object is to obtain a gas which does not contain more than a certain amount of dust after cleaning, and this should be the basis of comparison.

The dust content in the gas reported in this paper was not determined in all cases by the same apparatus at the different works; different methods were adopted as the result of individual experience. With skilled operators the differences in the methods employed in sampling should not appreciably affect the results obtained.

In the choice of a suitable cleaning plant, there are a number of points in addition to the actual final dust content of the gas which require careful consideration, such as power consumption, water supply, disposal of dust, and whether the dust is of any value for briquetting or for the recovery of potassium salts.

With wet cleaners, when the quantity of water is limited or the flue-dust is required for briquetting purposes, the installation of the Dorr thickener in conjunction with the cleaning plant enables the greater portion of the water to be recirculated, and the dust

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†London, England.

can be collected in the form of a thick sludge and run out into storage bays and dealt with as desired.

It was hoped at first to get definite information as to the indirect savings obtained by the various methods of cleaning, but this has proved too difficult to compute with any degree of accuracy, as there are so many factors which affect the results. In some cases, coincident with the installation of cleaning plant, hot blast stoves have been redesigned, different filling bricks put in, and new and more efficient types of burners have been introduced, all of which improvements have led to saving. On the other hand, full benefit is not being obtained in some cases, owing to the gas not being fully utilized pending alterations to other parts of the works. It is therefore practically impossible to estimate the indirect saving in refractories and repairs, due to the introduction of gas cleaning, which has, however, even under unfavorable conditions, more than justified itself by saving in cost of repairs and maintenance. In some cases a smaller number of stoves are being used and a higher blast temperature maintained, giving a greater blast-furnace efficiency.

A short description of each type of cleaner is given below, together with any special works conditions considered likely to affect materially the results obtained.

Wet Cleaning Plants

Plant I. Scrubber and Fan Washer—This plant is designed for cleaning for gas engines, and is cleaning 600,000 cu. ft. of gas per hour from 4 to 5 grm. down to 0.02 grm. per cu. m. The dirty gas enters the water spray cooling towers at a temperature of 190 deg. C., is cooled down to 37 deg. C., and leaves with a dust content of 0.8 to 1 grm. per cu. m. It then passes to a Jenkin fan in which water is injected in a fine spray, and, leaving this with a dust content of from 0.2 to 0.3 grm. per cu. m., it is finally cleaned to 0.02 grm. in a Theisen washer. The power consumed in this plant is 160 kw., which is equivalent to 0.275 unit per 1000 cu. ft. of gas cleaned; the water used for the same quantity of gas is about 30 gals. The cost for labor, power, stores, and repairs for this plant, according to works records for a three months' period, was 0.195d per 1000 cu. ft.

Plant II. Scrubber and Disintegrator—This plant is cleaning gas only for stoves and boilers, soaking pits, etc., and although the plant was designed for dealing with only 800,000 cu. ft. per hour, it is actually cleaning 1,250,000 cu. ft.

The crude gas containing 4 to 5 grm. per cu. m. is cooled in a Zschocke tower from about 80 to 140 deg. C. to 36 deg. C. It is then passed either into a Zschocke fan which reduces the dust content to 0.25 grm. per cu. m., or to a new Theisen disintegrator by which the dust content, if determined at a distance along the main at which all the spray has settled, is found to have been reduced to approximately 0.02 grm. per cu. m. The power and water consumed on this plant per 1000 cu. ft. of gas cleaned are respectively 0.08 unit and 11½ gals. when using the Zschocke fan, but with the Theisen disintegrator 0.13 unit and 13½ gals. are required. The total cost for labor, maintenance, and power on this plant over a prolonged period was given as 0.0896d. per 1000 cu. ft. of gas cleaned. During this period both the Zschocke fan and the Theisen disintegrator were working at different times.

Plant III. Wet Cleaner with Scrubbers, and Disintegrators—This plant is designed to wet-clean the gas

from four blast-furnaces, and is treating rather more than 5,000,000 cu. ft. per hour. The gas containing from 2 to 3 grm. per cu. m. is collected in a common main 9 ft. 3 in. in internal diameter, and enters three scrubbers at a temperature varying from 100 to 200 deg. C. These scrubbers are 72 ft. high and 15 ft. in diameter, and are packed with 134 tiers of wooden grids with 1½-in. spacings. Water is impinged on to a cast-iron plate from eighteen 2-in. nozzles to form a fine spray. The gas passes from the scrubber to three Theisen washers, each capable of dealing with 2,118,000 cu. ft. of gas per hour at N.T.P., and is finally dried in three cyclone driers 7 ft. in diameter and 16 ft. high, from which it is taken to the clean gas main and distributed to stoves and boilers. The clean gas leaves at a temperature of about 40 deg. C. and contains from 0.03 to 0.04 grm. of dust per cu. m. About 40 per cent of this gas is finally washed for gas engines in an old Theisen plant, but the power and water figures given apply only to the gas cleaning down to the condition required for stoves and boilers. The sludge from the cleaning plant is taken to a Dorr clarifier which enables nearly 90 per cent of the water to be recirculated. The clarifier, further details of which are given later, is 86 ft. in diameter and deals with 5000 gals. per min., and the clarified water passes to settling ponds, where it is cooled by 120 5/8-in. sprays and recirculated. The thickened sludge is disposed of as a waste product.

The power used by the circulating pumps and Dorr thickener is 0.038 kw.-hr. per 1000 cu. ft. of gas cleaned, and for the three Theisen washers 0.18 kw.-hr., giving a total of 0.218 kw.-hr. per 1000 cu. ft.; the water circulated and the make-up water are respectively 5.4 gals. and 0.6 gals. per 1000 cu. ft.

The plant has only recently been put into operation, so that maintenance and repairs are practically negligible. The labor required is two men per shift, which entails a charge of 0.006d. per 1000 cu. ft. of gas cleaned. The water is obtained from the river, so that the direct cost of cleaning the gas to the required condition for stoves and boilers works out, on the basis of power at ½d. a unit, as 0.115d. per 1000 cu. ft. of cleaned gas.

Plant IV. Brassert Tower and Theisen Disintegrator—This plant, which has only recently been started up, and will probably be considerably extended, has a capacity at present of 2,500,000 cu. ft. per hour, and is cleaning rather more than 2,000,000 cu. ft. per hour to the extent required for stoves, boilers, soaking pits, and reheating furnaces.

The plant consists of a single Brassert tower with sprays and hurdles to break up the water and gas. The tower is about 70 ft. high and 14 ft. in diameter, and the water circulated is about 50 gals. per 1000 cu. ft. of gas. The gas, containing about 6 grm. of dust per cu. m., enters the tower at a temperature between 180 and 240 deg. C., and leaves at about 20 to 25 deg. C. It then passes to one of two intermediate driers in which the excess of moisture is removed by a sudden reversal of the gas flow and by the gas impinging on fresh surfaces. The gas is then taken to one of two Theisen disintegrators, the second being in reserve as it is found necessary to thoroughly clean them out about once in six months. The water circulated in the Theisen machine is about 5 gals. per 1000 cu. ft. of gas cleaned. The gas is then passed into one of two Bischoff driers by which the mechanically held moisture is removed by baffles and frequent reversals of the

direction of flow of the gas. The final gas contains from 0.15 to 0.20 grm. of dust per cu. m. under the present working conditions.

An interesting series of tests was carried out at this plant on the effect of varying the quantity of circulating water in the tower and in the disintegrator; they showed that in both parts of the cleaner the quantity of water could be very considerably reduced without any reduction in the cleaning of the gas, but in practice it has been found that if the minimum amount of water be used, which is about 25 gals. on the tower and 3 gals. on the Theisen machine per 1000 cu. ft., the Theisen disintegrator rapidly furs up. This plant is so situated that the charge for the water supply represents only the cost of the power for circulation, and this amounts to a difference of only about 0.01 unit per 1000 cu. ft. for the additional water. The actual power used was given as 0.15 unit per 1000 cu. ft. The labor to run the plant is two men per shift and supervision which amounts to 0.024d. per 1000 cu. ft.

As regards repairs and maintenance, the plant is practically new and has only been running a few months, so that no figures are available, but it would appear that these should be very low, as the whole system consists merely of circulating pumps. The six-monthly clean and overhaul of the Theisen is carried out by the operators on the plant with the help of fitters, etc., and is estimated to cost about £4 to £5 each time.

The capital cost of this plant was about £17,400.

PLANT V—Results Obtained Using No. 1 Brassert Tower for October and November, 1927.

Date Oct. 1927	Dust Content of Clean Gas. Grm. per cu. m.		Date Nov. 1927	Dust Content of Clean Gas. Grm. per cu. m.	
	First sample	Second sample		First sample	Second sample
1	0.500	.....	1	0.332	0.300
3	0.561	0.648	3	0.449	0.520
4	0.676	0.618	4	0.268	0.485
5	0.348	0.451	5	0.343	.....
6	0.538	0.449	7	0.389	0.332
7	0.547	0.559	8	0.343	0.353
8	0.650	.....	9	0.353	0.360
10	0.343	0.511	10	0.385	0.405
11	0.449	0.596	12	0.362	.....
12	0.357	0.279	14	0.362	0.394
13	0.424	0.353	15	0.311	0.350
14	0.378	0.362	16	0.428	0.348
15	0.529	.....	18	0.366	0.362
17	0.602	0.678	19	0.364	.....
18	0.600	0.520	21	0.307	.....
19	0.650	0.706	22	0.332	0.300
20	0.599	0.522	23	0.366	0.284
21	0.556	0.398	24	0.350	0.334
22	0.472	.....	25	0.311	.....
24	0.511	0.538	26	0.380	.....
25	0.371	0.247	28	0.252	.....
26	0.518	0.344	30	0.318	.....
27	0.481	0.650			
28	0.247	.....			
29	0.199	.....			
31	0.499	0.366			

Average temperature of inlet water to towers, 20 to 25 deg. C.

Average temperature of clean gas leaving plant, 20 to 25 deg. C.

Average temperature of overflow water from Dorr thickener, 10 to 13 deg. C.

Plant V. Brassert Scrubbers and Sprays without Disintegrators—This plant is similar in some respects to Plant IV., in that it is a Brassert washer, but it differs in that Theisen disintegrators are not installed in con-

junction with the towers. The plant consists of two Brassert washers 15 ft. in diameter, No. 1 being 86 ft. high and fitted with a bottom cone, and No. 2, of later design, being 65 ft. high and having no such cone, and has a capacity of about 5,000,000 cu. ft. per hour.

At present No. 1 washer only is in use, owing to the blast-furnace plant not being in full operation, and 2,750,000 cu. ft. of gas are being cleaned per hour. The tower is packed with wooden hurdles on to which jets of water are sprayed, the gas in its upward journey being intimately mixed with the down-flowing spray of water. The gas before leaving the tower is subjected to a high velocity water spray, and after being made to turn a number of double bends it enters the drier or mud catcher tangentially. This is a cylindrical chamber, the bottom of which tapers into the down-comer main for the gas. The centrifugal force due to the tangential entry throws the coarser moisture particles to the sides of the cylinder, and this is assisted by a high-pressure spray of water in a very fine state of division impinging on the stream of gas from above which serves as a carrier of the moisture particles to the sides of the tube. This moisture-containing fine dust is trapped in an expanded part of the down-comer, and is drawn off, the cleaned and partially dried gas passing along the main, where it is further dried by a sharp change of direction at the bottom of the down-comer. It then enters the clean gas main feeding the stoves, boilers, etc. This main is fitted with drain cocks every 50 ft., which are opened every 24 hours. Fig. 1 is a sketch showing the construction of the Brassert tower and spray drier.

The water and sludge are taken in an open culvert to the Dorr thickener, which is 86 ft. in diameter. The clarified water passes to a hot well, and is then pumped up into a cooling tower and recirculated. The sludge is run out into bays and allowed to dry; it is proposed to put down a sintering plant to treat this material for the blast-furnace plant.

The gas, containing 5 to 6 grm. of dust per cu. m., first enters a primary dust catcher of the cyclone type and then enters the Brassert tower. It enters the clean gas main with a dust content of about 0.4 to 0.5 grm. per cu. m.

The total water required for the operation amounts to 29 to 37 gals., and the power required is 0.029 unit per 1000 cu. ft. of gas cleaned. The make-up water due to wastage and loss with sludge amounts to approximately 5 per cent, say, 1½ to 2 gals. per 1000 cu. ft. of gas. In the opposite column is a table showing the temperature of the gas and water at various points on the system and gas analyses over a period of several weeks.

The labor in this plant is not considered, as the pumps have all been installed in the existing pump-house and have entailed no extra men for operation. The washery itself is visited by the stove tenders at regular times, but no extra men have been employed since the plant was put into operation. Actually a proportion of these men's time should be allocated to the gas-cleaning plant, but it was not possible to obtain any figure for this. As regards repairs, the plant has only been running a few months and no figure can as yet be given.

A short description of the Dorr clarifier as installed to deal with blast-furnace slurry may be of interest. The apparatus installed at Plant V consists of a circular tank 86 ft. in diameter into which the

slurry is brought. There are four arms fitted to a vertical rotating shaft, two long and two rather shorter, which make one revolution in 20 minutes, drawing the settled sludge to the center, whence it is discharged by special sludge pumps. The power expended is very low and is included in the figure given above. A typical test of the clarifying effect of this apparatus is as follows:

Grains per cu. ft.	
Inlet water	—32.45 suspended solids, 98.42 in solution.
Outlet water	— 3.39 suspended solids, 93.91 in solution.

The amount of dried sludge obtained from the Dorr thickener is about 3 tons per day, of which the following is a typical analysis:

Per cent	
FeO	23.04
Fe ₂ O ₃	37.43
SiO ₂	10.48
CaO	4.60
MgO	Trace
SO ₃	1.45
P ₂ O ₅	0.133
MnO	1.67
Al ₂ O ₃	11.40
Loss of ignition	8.40

} total iron = 44.20 per cent

The capital cost of the Brassert towers, Dorr thickener, etc., was given as £30,000.

Dry Cleaners

Plant VI. Lodge-Cottrell, Pipe Treater Type—This plant was designed to clean 2,000,000 cu. ft. of gas per hour, but as the output of the blast-furnaces has been increased since its installation, it is estimated that it is dealing with about 3,000,000 cu. ft. of gas per hour. It is of the "pipe treater" type, and consists of six compartments, each containing 64 pipes, through which a nichrome wire is suspended from an insula-

PLANT VI—Dust Content and Temperature of Blast-Furnace Gas During May, 1927, Taken from the Lodge-Cottrell Gas-Cleaning Plant (Pipe Treater).

Date of analysis	Dust Content		Gas Temperatures	
	Before Cleaning.	After Cleaning.	Before Cleaning.	After Cleaning.
May, 1927	Grm. per cu. m.	Grm. per cu. m.	deg. C.	deg. C.
2	3.30	0.34	215	138
3	6.20	0.60	184	127
4	4.32	0.52	240	166
5	4.60	0.44	217	142
9	6.40	0.50	178	124
10	6.20	0.58	180	118
16	5.64	0.52	213	149
17	5.42	0.66	247	166
18	4.74	0.60	192	133
19	6.62	0.58	240	160
23	6.42	0.56	260	184
24	4.82	0.52	247	188
25	5.60	0.52	238	160
26	4.26	0.46	195	150
30	5.40	0.46	220	154
31	7.30	0.56	244	160

tor above. The dust is deposited on the inner walls of the tubes by the electrical discharge. Each battery of tubes is fitted with its own separate electrical unit, and is mechanically rapped every hour to shake the dust down, the current being temporarily cut off. It is probable that a considerable amount of the dust

which is found in the clean gas test is brought over immediately after opening up the compartments after rapping, as it is not possible in practice to give the dust sufficient time to settle completely in the hopper after rapping.

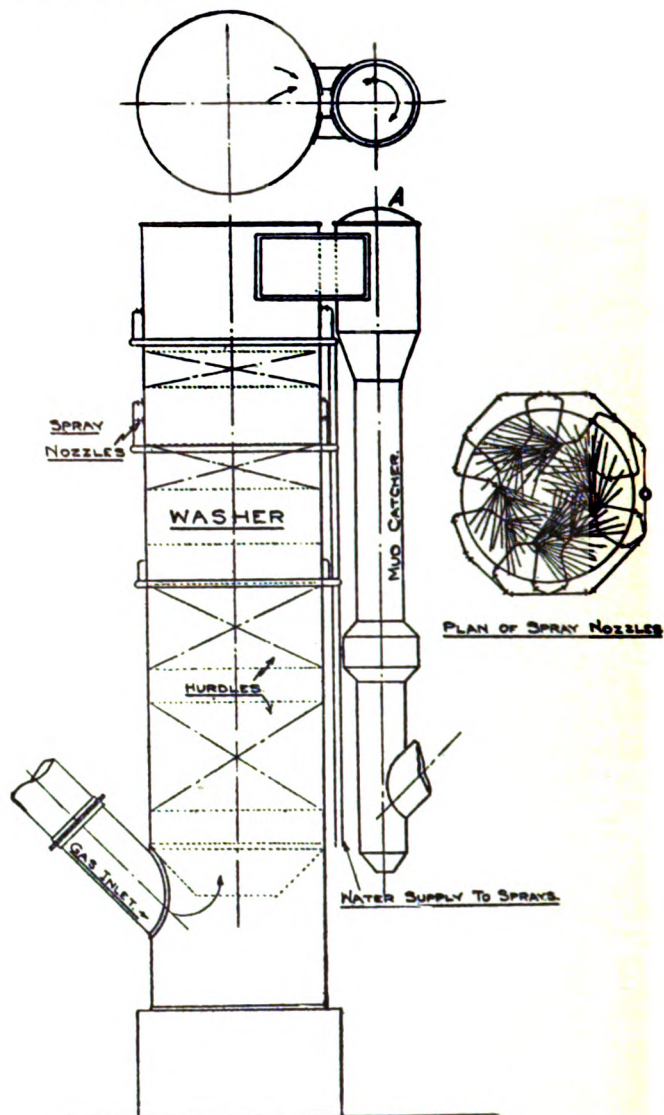


FIG. 1—Brassert washing tower and mud catcher. The gas on leaving the spraying tower, in which the coarser dust is removed, enters the mud catcher tangentially, whereby some of the moisture, carrying dust with it, is deposited on the sides of the tube. The atomizing water spray at (A) impinging on the gas from above at high pressure carries the finer moisture particles to the tube surface. The wet slurry is trapped in the expanded part of the tube and withdrawn.

The plant has been in operation for some years, and considerable difficulties were met with in the early stages in the choice of suitable wires for the discharge electrodes; this difficulty has now been overcome by the use of nichrome wires. The author was also informed that considerable improvements have been made in the rectifiers and insulators, which now give very little trouble. The gas enters the cleaner containing on an average 5 to 6 grm. of dust per cu. m. and at a temperature of from 180 to 230 deg. C.; it is cleaned down to a dust content of from 0.4 to 0.6 grm. per cu. m. and leaves the apparatus at a temperature of from 120 to 180 deg. C. It was stated that the inlet temperature could rise to 425 deg.

C. without causing trouble. Details of tests taken over a period of one month are given herewith.

The dust content is considered to be higher than would be the case if the plant were working to its designed capacity, but, on the other hand, the cost of cleaning per 1000 cu. ft. would be materially increased. The considerable difficulty encountered at first in handling the dry dust from the apparatus has been overcome by discharging it into a culvert and flushing it away by water; by this means the labor is reduced.

One chamber is laid off every month for a complete clean out and overhaul. The power used in the plant amounts to about 0.013 unit per 1000 cu. ft., and the labor required is three men per shift and a foreman on day shift. The cost of labor amounts to 0.0181d. per 1000 cu. ft. of gas cleaned.

Stores and repairs over a period were given as costing 0.0023d. per 1000 cu. ft. and the overall cost of cleaning—power, labor, and repairs, stores, renewals—amounted to 0.026d.

The capital cost of a similar plant at today's prices would be approximately £30,000.

Plant VII. Lodge-Cottrell, Plate Treater Type—
This plant is composed of eight chambers, through which the gas is passed in parallel. The insulated wires are suspended between vertical plates which take the place of the tubes in the pipe treater type; the dust is deposited on the plates by the electric discharge from the insulated wires, which are charged with unidirectional current at high tension. Each chamber is fitted with two sets of plates, the gas being thus cleaned in two stages. About 2,000,000 cu. ft. of gas per hour containing about 5 grm. per cu. m. are passed, and the cleaned gas, carrying on an average 0.4 grm. per cu. m. is used under stoves and boilers. Trouble was encountered in the early days with the breakage of the insulators, but improvements have increased the average life of an insulator to about 12 months. The dust in this plant is removed by hand-labor, and is rather difficult to handle owing to much of it being very fine in character; a considerable proportion of the wages cost is spent in dealing with this material, which at the present time has no market value.

The amount of dust recovered per week amounts to about 35 tons, which is equivalent to approximately 3.75 grm. per cu. m. of gas cleaned, and forms a fairly accurate check on the percentage extraction of the plant.

The cost of power consumed on the plant over a period was given as 0.03d., wages 0.014d., insulators 0.001d., repairs and stores 0.0015 d., making the total actual working costs for this plant 0.0465d. per 1000 cu. ft. of gas cleaned.

The capital cost of the plant was given as £20,000.

Plant VIII. Lodge-Cottrell, Plate Treater Type—

This plant is designed to treat 6,000,000 cu. ft. of gas per hour. It consists of 12 chambers working in parallel; each chamber is fitted with four banks of electrodes, the two banks on the crude side being worked in each case from electrical units separate from those on the clean main side; so that one side of the treater acts as a crude dust cleaner and the other side as a final dust cleaner. The installation consists of six electrical units, but only four have been put into service, as the plant has not yet operated

at full capacity owing to the blast-furnace department not working at its maximum output. Two of the electrical machines operate the crude gas side of the plant, the others the semi-clean gas side. The dirty gas usually contains from 4 to 6 grm. of dust per cu. m. and enters the plant at about 200 deg. C. A drop

PLANT VIII—Lodge-Cottrell Plant (Plate Type).

Date	Gas temperatures		Dust in gas		Percentage of calcined ore used in blast-furnace	
	Dirty gas deg. C.	Clean gas deg. C.	Dirty gas Grm. per cu. m.	Clean gas Grm. per cu. m.		
1927						
Oct. 5...	237	150	8.55	0.56	58.3	
Oct. 11...	183	112	4.65	0.25		
Oct. 12...	232	141	4.90	0.50		
Oct. 13...	204	136	3.70	0.31		
Oct. 14...	217	114	4.35	0.49	58.3	
Average	214.6	130.6	5.23	0.42		
Nov. 16...	181	95	4.00	0.19		41.7
Nov. 17..	175	111	2.05	0.17		
Nov. 18...	163	89	11.00	0.13		
Nov. 21...	170	85	3.76	0.24		
Nov. 22..	137	80	3.53	0.07	41.7	
Nov. 23...	196	110	3.13	0.39		
Nov. 24..	200	106	2.94	0.34		
Nov. 28..	181	103	2.90	0.10		
Nov. 30...	176	89	5.28	0.09	41.7	
Dec. 8...	153	89	2.47	0.05		
Average	173.2	95.7	4.10	0.17		
1928						
Jan. 4...	218	98	10.9	0.49	75.0	
Jan. 5...	254	119	6.61	0.96		
Jan. 10...	208	86	2.42	0.39		
Average	226.7	101.0	6.64	0.61	75.0	

During the whole of the period only four of the electrical machines were in operation.

in pressure of 0.5 to 0.6 in. water-gauge and in temperature of about 100 deg. C. occurs during its passage through the apparatus, and a final dust content of about 0.3 grm. per cu. m. is usually found in the clean gas.

At these works the blast-furnace practice varies considerably from time to time, according to the varying proportion of calcined and raw ore used, and this has a very considerable bearing on the dust content of both the dirty and clean gas. In the above table is given a series of actual tests carried out on different ore burdens illustrating this effect.

The labor required to operate the plant is one man per shift, and one man cleaning out on day shift only. The dust is withdrawn in the dry state from the hoppers into wagons and is somewhat difficult to handle; it has no market value. The power required to work the plant (that is, four machines) is 0.0225 unit; wages, including dust disposal, cost 0.0063d., and stores 0.0017d. per 1000 cu. ft.

The plant has only been put into operation comparatively recently, and, as is frequently the case, there has been a certain amount of trouble in the early stages; consequently, maintenance, replacements, and engineers' time on the plant have been considerably in excess of what will be normally expected, and these figures are therefore not included. It is believed that these troubles were only such as are usually met with in starting up a new plant, and that before long they will be to a great extent overcome.

The capital cost of this plant was given as £55,000.

(To be continued)

British and American Automotive Steels

Features of Difference Exist in the Chemical Specifications,
Resulting in Less Difficult Heat Treatments on Parts in the
American Practice—Ford Methods Particularly Are Cited

By J. W. URQUHART*

PART I

THE very comprehensive series of disclosures that have recently been made in England of what would appear to be a fairly representative American system of trade automobile construction suggests a timely opportunity for commenting upon the differences that may occur between the practices followed by the two leading countries in the production of a certain class of automobile.

The allusion made is, of course, in reference to the system followed by the Ford organization in the production of that company's celebrated medium-priced car, in which remarkable efficiency in performance is only matched by outstanding endurance under rough usage and often ill-treatment. No other low priced chassis known generally in Europe has appeared to be capable of withstanding the conditions under which the Ford production has made good. The engineer's notice is at once attracted to the nature of the material used in the chassis, and particularly to its heat treatment and standardization throughout these two features.

Divergence from European Practice

The most outstanding feature of divergence from the common practice of Europe (always in reference to the above class of car) is undoubtedly the almost complete dependence by the Ford organization upon the carbon steels, virtually neglecting the alloy materials, notably the extensive range of steels in which nickel is the chief alloying constituent. It will be particularly noticed that the carbon steels used by the above organization bear a large percentage of manganese and chromium, which are well known from their hardening effect.

For mere purposes of comparison, the range of what are regarded in Europe as commercial-use carbon steels, as employed by the Ford organization, is given below:

From a careful consideration of the kinds of steels above listed, it would appear to the average automobile engineer that the outstanding feature of material difference between the chassis construction of the

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Ford class and the same type of work in Europe lies in the chemical composition of the steels employed.

Purposes for Which Above Steels Are Used

Type steel and heat treatment	Hardness No.	Used on
A—Carburize at 1,650–1,750 deg. F., to depth of — in. Heat in cyanide to 1,650 deg. F. Quench in oil. Draw in oil to 400 deg. F.	Scleroscope 75–85 on tooth, Brinell 255–340 when copper plated.	Driving pinion
AA — 1,500 deg. F. Quench in soluble oil or soap solution at 980 deg. F. Draw.	Brinell 286–231.	Connecting rod. Transmission shaft. Crankshaft. Drive shaft. Wheel spindle.
AAA—1,500 deg. F. in cyanide. Quench in oil. Draw at 400 deg. F.	Brinell 364–444.	Differential driving gears. Transmission gears.
DD — 1,500 deg. F. Quench in oil. Draw in oil at 250 deg. F.	Brinell 418–444.	Spring leaves.
G—1,750 deg. F. Carburize 1,450 deg. F. Quench in water. Draw at 380 deg. F. in oil.	Scleroscope 75–85.	Drive shaft sleeve.
H—1,560 deg. F. in cyanide. Quench in press.	Rockwell C 35–50.	Clutch plates.
E—1,500 deg. F. Quench in soluble oil or soap solution to 500 deg. F. Anneal at 980 deg. F.	Brinell 269–321.	Front axle. Spring perch. Transmission pedals. Fender supports.
EE — 1,480 deg. F. Quench in water to 400 deg. F. Draw at 450 deg. F.	Brinell 364–477.	Drive shaft roller bearing housing.

In the first type we find that the desirable degree of hardness in most of the steels is dependent upon manganese and chromium, rather than upon a high carbon content, whereas in the second type a higher carbon content would be commonly employed, together with a lower manganese percentage and possibly no chromium whatever.

CHEMICAL ANALYSIS OF STEELS

Type of steel. Ford designation.	Carbon	Manganese	Chromium	Vanadium	Tungsten	Silicon	Phosphorus max.	Sulphur max.
A	0.17–0.22	0.60–0.75	0.65–0.80	0.12–0.15	.....	0.10–0.15	0.03	0.04
AA	0.26–0.32	0.65–0.80	0.80–1.00	.....	.....	0.10–0.20	0.03	0.04
AAA	0.30–0.35	0.65–0.80	0.90–1.10	.....	.....	0.10–0.20	0.03	0.04
DD	0.48–0.52	0.80–0.95	1.00–1.20	.....	.....	0.10–0.20	0.03	0.04
G	0.15–0.20	0.30–0.45	.....	.....	.....	0.07–0.15	0.04	0.05
H	0.27–0.37	0.45–0.60	.....	.....	.....	0.07–0.15	0.04	0.05
E	0.27–0.35	0.70–0.90	.....	.....	.....	0.07–0.15	0.04	0.05
EE	0.35–0.40	0.70–0.90	.....	.....	.....	0.07–0.15	0.04	0.05

CARBON NICKEL-CHROME STEELS IN GENERAL USE IN EUROPEAN PRACTICE

The following tests were taken from longitudinal pieces cut from bars treated by oil hardening (except the air hardened specimens) and tempered by 600 deg. C. All tests taken transversely of the direction of rolling.

Type of steel	Carbon per cent	Manganese per cent	Nickel per cent	Chromium per cent	Yield point tons per sq. in.	Maximum load tons per sq. in.	Elongation per cent on 2 in.	Reduction of area per cent	Izod impact figure
2 per cent Nickel:									
Medium low chrome	0.3-0.4	0.3-0.6	1.5-2.5	0.5-1.0	30	40-45	25	50	50
Medium high chrome	0.3-0.4	0.3-0.6	1.5-2.5	1.0-1.7	40	55-65	18	35	20
3½ per cent Nickel:									
Mild	0.15-0.25	.....	.....	.....	40	50-60	19	55	40
Medium	0.25-0.35	0.25-0.55	3.25-4.0	0.4-0.8	45	55-65	18	50	35
Hard	0.3-0.4	.....	.....	.....	50	60-70	17	40	25
Air hardening:									
Nickel-chrome—thin steel section	0.28	0.35-0.55	3.5-4.25	1.0-1.5	75	100-125	8	20	8
	0.26	0.35-0.55	3.5-4.25	1.0-1.5	45	55-65	15	45	35

Now, the obvious advantage gained by a higher percentage of both of the hardening constituents mentioned has special reference to the influence of heat treatment. To obtain an automobile component of the ultimate hardness and toughness, together with desirable resilience in carbon steel, with a minimum of manganese, very considerable skill in heat treatment is called for. In the first place, the grain-refining phase, together with the quenching temperature will be some hundred degrees higher than the figures given in the above tables. The quenching medium must be water or cold oil, involving increased risk of both deformation and cracking—in plain words, skilled heat treatment.

Take, then, by comparison, a steel fairly rich in manganese and chromium, thus permitting a low carbon content for a given ultimate Brinell hardness. Both the resolving and the quenching temperatures may here be considerably lower than in the case of carbon steel. Hence, it is to be presumed, the advantage presented by the practical elimination of really skilled heat treating, and an important cost reduction is in prospect, at least on the questions of labor and time.

All of the commercial carbon steels in use in automobile work contain manganese for the reduction of

oxides, and to counteract the baneful influence of sulphate of iron by converting the sulphur into the relatively innocuous manganese sulphide; but the important part played by manganese in the steels tabulated is of much greater moment. Not only does it confer a desirable degree of hardness, in the presence of a minute percentage of carbon, but it renders the operation of hardening in the heat treatment possible in oil or suds quench, from a very moderate temperature, and so escapes the common risks of drastic quenching.

The presence of chromium in the steels tabulated insures not only added hardness, in the presence of small percentages of carbon, but produces a very pronounced refining effect upon the grain structure of the mass of the steel, an effect which is at once apparent upon examining a fracture-face of a steel of this type, either by the naked eye or microscope.

It cannot be shown, however, that the chromium constituent of the steel has any appreciable effect in assisting the manganese to lower the upper critical point; in fact, it rather tends to raise it, while at the same time tending to suppress the formation of pearlite on cooling. Chromium in the small percentages used has a retarding influence in the rate at which tempering occurs. As used by the organization

IMPACT RESISTANCE AND TENSILE STRENGTH OF THE GEAR FORGING STEELS

All Tests Are Taken Transversely to the Direction of Forging or Rolling

Description of steel and treatment	Carbon %	Manganese %	Nickel %	Chromium %	Elastic limit tons per sq.in.	Yield point tons per sq.in.	Maximum load tons per sq. in.	Elongation % on 2"	Reduction of area %	Izod impact figure
CARBON STEEL										
Forging quenched in oil and tempered	0.34	0.68	....	....	15	18	35.0	30	54	16
Forging quenched in water and tempered	0.34	0.68	....	....	18	24.8	35.5	20	42	15
NICKEL STEEL										
Large forging oil hardened and tempered	0.37	0.61	3.55	....	24	28	44.8	22	45	18
Small forging oil hardened and tempered	0.36	0.55	3.65	....	29	32	46.0	20	30	26
NICKEL-CHROME STEEL										
Large forging oil hardened and tempered	0.28	0.40	3.59	0.51	27	32.7	43.6	21.5	53	32
Small forging oil hardened and tempered	0.26	0.66	3.53	0.84	31	38.8	48.7	21	56	59

NOTE—The 2-3½ per cent nickel steel is widely used in crank shafts, axles and steering gear. In the best quality cars many makers use this type for frame members also. The "mild" type is much used in heavy lorry work. The "medium" is much used in aero engines. The hard type is used for highly stressed parts, including connecting rods, propeller shafts and the toothed gears in gear boxes.

in question, the steel of carbon-manganese-chromium makes a very effective spring leaf in spite of considerable engineering opinion in opposition to such uses for steel of this composition.

The particular steel in view (DD) shows 0.48-0.52 carbon, the chromium constituent being 1.00-1.20 per cent. In European practice the carbon would tend to work out at 0.55-0.65 per cent.

Depth of Hardening in Automobile Work

Consideration of sectional areas in automobile steel components, together with the stressful nature of the treatment all of the parts must withstand in the operation of the machine, suggests that, since each component must be as light as possible, the hardened area in each part must extend throughout its mass. Seldom is it permissible to tolerate the employment of hard exterior and merely tough (softer) core components. In the production of massive pieces of machinery, as the axles of locomotives, homogeneous conditions are very difficult to attain, if they are ever fully attained. We have here the core drilling, so as to expose the interior to some of the hardening influence of the quenching medium, but even then the exterior is commonly the harder of the two areas.

No such hardening depths are required in automobile work, and the whole matter is thus much simplified, provided that a sufficient percentage of manganese and chromium is present in the composition of the steel used. In automobile work, in most of the parts, cross section is so small that even carbon steel, without an appreciable percentage of manganese, can permit of homogeneous hardness, provided the heat treatment is correct. This, however, presupposes the employment of high quenching temperature, and cold quenching media.

For this reason, then, the employment of both manganese and chromium in a low carbon steel is justified; the hardened depth conferred by both of these constituents being the outstanding feature of such steels.

Taking the case of automobile spring leaves, it is essential that all of the section here shall contribute impartially to the resilience of the spring—the leaf must be hard throughout. This condition, as is well known, can be produced successfully in a plain carbon steel.

Immense quantities of such plain carbon vehicle springs are in use, yielding satisfactory service. The labor costs of such springs are, however, an unnecessarily high percentage of the whole. It is for this reason, doubtless, that the manufacturing concern in question favors the policy of using such steels as will permit of a homogeneous hardening to a considerable depth without the necessity for drastic heat treatment. In plain words, the manufacturer of the steel is required to produce material that can be heat treated in a safe and simple manner, at small cost for this operation. In this way we may regard the higher cost of such steels as including some of the cost that would be incurred if plain carbon steels were used. Obviously, if the cost of heat treatment can, in this way, be minimized, the policy is all to the good. Steel making is now conducted under such efficient control that the product can be relied upon as uniform throughout large tonnages. The product of even skilled heat treaters, handling plain carbon steel, does not guarantee such uniformity. One leading reason

for the good service of the particular product is not far to seek.

It should not be inferred, from the above observations, that automobile components of European origin rely upon the plain carbon steels, and that full account is not taken of the whole range of the modern alloy steels.

If any useful inference can be drawn, it is that a particular concern in the United States has "gone one better" in the production of a remarkable automobile, partly by the simple policy of transferring to the steel makers much of the prospective cost of skillful heat treating, and, in the writer's opinion, teaching the automobile makers of every country a useful lesson.

United States Has Over 12,000,000 Developed Horsepower from Water

The developed water power in the United States on January 1, 1928, was 12,296,000 hp., showing an increase of 575,000 hp., or approximately 5 per cent, during 1927; and the total amount of potential water power available 90 per cent of the time is 38,110,000 hp. and that available 50 per cent of the time is 59,166,000 hp., according to an announcement by the Department of the Interior, through the Geological Survey. The figures for potential water power are not directly comparable with the figures for developed water power, because the figures for developed power are given in terms of the capacity of the installed water wheels, which may be several times the potential power available 90 per cent of the time. Estimates based on studies of the capacity of water wheels installed at fully developed water-power sites indicate that about 15 per cent of the potential water power of the United States is developed at the present time. If it were feasible to develop all the water-power resources of the United States, the total capacity of water wheels installed at all water-power plants would amount to about 85,000,000 hp.

All of the increase in developed water power in 1927 was in the plants of public-utility power companies, the capacity of water wheels in manufacturing plants showing a small decrease during the year. California still ranks first in developed water power, with a total of 1,993,000 hp. of water wheels in water-plants. New York, with 1,779,000 hp., is second, and Washington, with 707,000 hp., is third. The rest of the 10 leading water-power states are all east of the Mississippi River.

The estimate of potential water power in the United States has been revised to include the results of recent studies and surveys, particularly in the upper Columbia River basin and the Tennessee River basin. Washington, with 11,200,000 hp. available 50 per cent of the time, leads all the states in water-power resources by a wide margin. It is followed by California with 6,700,000 hp., Oregon with 5,900,000 hp., and New York with 5,000,000 hp., these figures representing power available 50 per cent of the time at an efficiency of 70 per cent. Most of the undeveloped power in New York is on the Niagara and St. Lawrence rivers.

Copies of the report giving by states the developed water power on January 1, 1928, and the estimated potential water power available 90 per cent of the time and 50 per cent of the time can be obtained by application to the director, Geological Survey, Washington, D. C., or to any of the district or subdistrict offices of the Geological Survey.

Sheet Steel for Automobile Bodies

Equipment and Methods of Pickling and Cold Rolling Steel

Sheets—The Chemical Action in Pickling—Physical

Changes Resulting from Cold Rolling

"AUTOSHEET"

PART V

THE pickling of automobile body sheet steel is essentially the removal of scale or oxides adhering to its surface. This removal of scale is carried out by immersing the sheets in a weak acid solution with the temperature of the acid bath raised to accelerate the action. The sheets from the hot mill or annealing usually bear a slight scale over the metallic skin which in turn lies next to the steel base and the object of pickling is to remove only this oxide, or scale without the acid attacking the metallic skin and base metal. Theoretically this may seem quite easily done but there are many factors to be contended with which will reveal themselves very shortly.

Regardless of the variables present the pickling processes gives us a clean, smooth sheet suitable for the application of protective coatings such as lead, zinc, tin and enamel. So far as we are now concerned, the pickled sheet is smooth enough to be drawn in a die to the shape of the body part intended and except for a protective coating of oil the automobile sheet goes from the mill to the consumer free from any of the above mentioned coatings. This exposure of the base metal demands a rigid inspection as the surface finish must not only be perfect in appearance but free from any defects such as scale which might cause trouble in forming. A scaly surfaced sheet when drawn may badly score or scratch the die and usually will result in an uneven pulling of the sheet and a broken stamping.

Single and Full Pickled Sheets

From the automobile body consumer's standpoint he is interested in the surface of the steel designated to him, by

the mill, as "single pickled" or "full pickled" sheets. The term "single pickled" is self-descriptive and usually means that the sheet has only one pickle or cleansing from scale in its entire process. This pickling usually occurs before cold rolling and annealing as scale would be injurious to both of these operations. Therefore, in single pickled material, sheet mills for the most part pickle the sheets as they come from the hot mill rolls in the form of black sheets and this is termed "black pickling." It is natural and correct to expect only a fair surface from a single pickled sheet. Sheets of this nature are used on such parts as are

partially, if not wholly, concealed and require little or no surface finish and usually only a moderate amount of drawing.

On the other hand we have a full pickled sheet which is used on all automobile parts which require a perfectly smooth and clean surface for painting and for general appearance on exposed body parts. Full pickled sheets receive two or more picklings during their processing, the number of picklings varying in different mills as the steel is processed for the various body parts. Thus we may give a full pickled sheet its first pickling either by cleaning the sheet bar or the breakdown sheet. If the sheet bars or breakdown sheets are pickled no further cleansing is done until the sheets have been annealed. If the sheets receive a cold rolling after their anneal as the final operation to their processing, the pickling will come before the cold rolling. Pickling carried out after the annealing is designated in the mill as "white pickling."

Kinds of Scale

Before discussing the removal of scale the va-

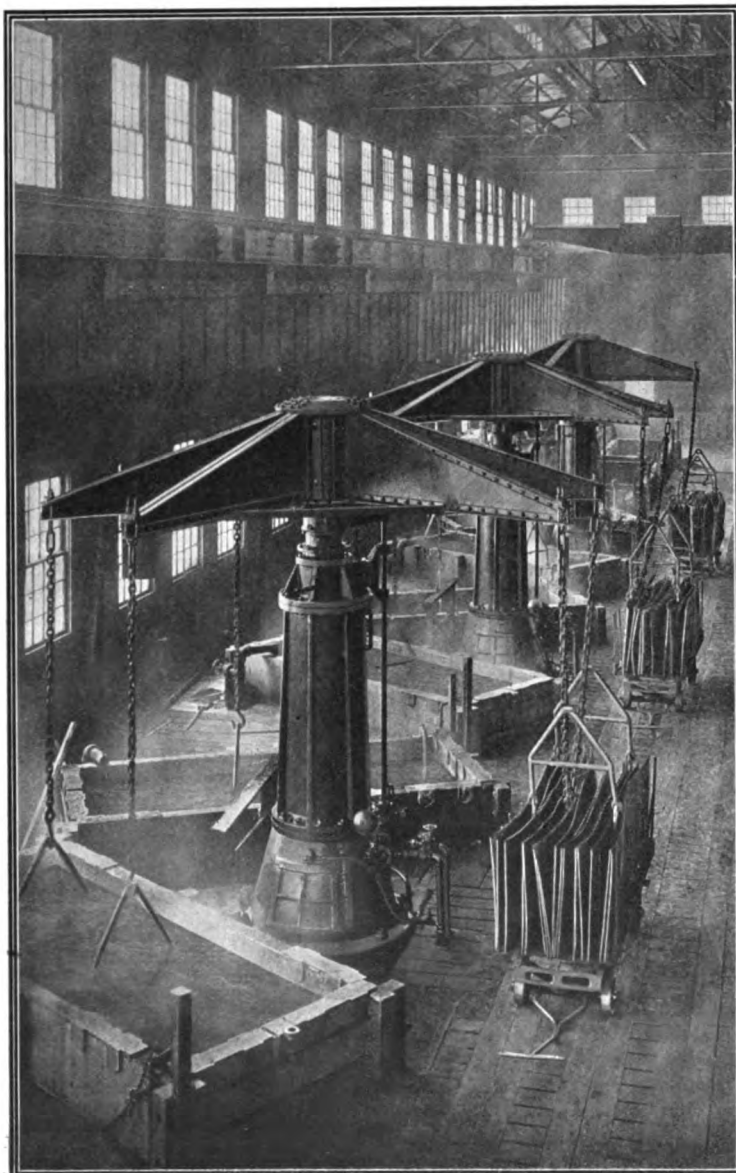


FIG. 1—Plunging type pickler (Mesta).

rious kinds are worthy of summarizing as they exist in various forms some of which are harder to remove than others. The different kinds of oxides or scale are dependant on such factors as:

- 1—The nature of the steel (high or low carbon).
- 2—Oxygen present causing oxidation of the steel.
- 3—Presence or absence of water.
- 4—Temperature of rolling or annealing.
- 5—Pressure of rolling.
- 6—Time involved either in mechanical or thermal treatment.
- 7—Atmospheric conditions.

From such factors as these the heating of a low carbon ingot in the soaking pits produces a heavy Fe_3O_4 - Fe_2O_3 scale which is usually mechanically removed in the blooming mill. However in rolling to the sheet bar form, the relatively high temperature of the steel under pressure and in the presence of water produces a compact, hard plate-like scale of Fe_3O_4 which requires about a 10 per cent solution of sulphuric acid (H_2SO_4) at a high temperature (160 deg. to 175 deg. F.) for its satisfactory removal.

In rolling out the sheet bar to breakdowns we produce a magnetic oxide Fe_3O_4 similar to the above which requires about the same strength of acid and the same temperature to remove although less time is necessary due to the increased surface area available for the pickling acid. As previously mentioned this scale can be removed either from the sheet bar or breakdown sheet if it is to be a full pickled sheet.

The hot finishing of the breakdowns to the black finished sheet is made under rapidly falling temperature, pressure and oxidation, and while a similar oxide Fe_3O_4 is formed it is less injurious as the scale has been removed from it when the sheet was in the form of a sheet bar or breakdown and therefore may pass through an annealing operation before sufficient oxide has again collected on its surface to warrant another pickling operation.

The oxides from annealing are formed in the absence of both pressure and water, are very dry and grainy and are usually removed in a 6 per cent to 10 per cent solution of acid at a temperature ranging from 140 deg. to 160 deg. F. This oxide of annealing is usually Fe_2O_3 which increases with temperature and available oxygen, and ranges in color from light yellow (low temperature) to a reddish blue or deep blue (high temperature). This oxide is usually only around the edges of the sheet which have become oxidized by the heat of the anneal. As a general rule the oxide border is 2 in. to 4 in. wide and leaves the center of the sheet clean and white. Sheets near the top of the pile have a wider and darker border due to a higher temperature near the top of the annealing box and less pressure of the sheets piled on them to prevent the hot oxidizing gas from creeping in toward the center of the sheets.

Pickling Equipment

The methods employed in most of our leading sheet mills for the pickling of automobile sheets center around two types of apparatus. One is known as the surging type while the other is designated as the plunger type. In both cases the sheets are stood on edge in a rack either between upright pins or slots which keep the sheets apart. This edging of the sheets exposes the entire surface for the action of the acid

and allows the ready escape of the gas evolved as well as a maximum speed in pickling.

The so-called surging type involves a severe agitation of the acid solution through the rack of sheets held in a vertical position in the tank or "tub." This tank is usually built of wood and held together by acid resisting bronze bolts and nuts. The inside dimensions of the tank are about 15 or 16 ft. long, 5 or 6 ft. wide and 6 to 7 ft. in depth and it is set into the ground so that about 2½ ft. of the tub is above the level of the pickling floor. One side of the tank has a partition of about 14 to 16 in. in width which runs to within 5 or 6 in. of the bottom. This partition contains a solid wooden plunger which, by suitable mechanical connections, moves up and down thus forcing the acid in and out of this compartment into the tank proper and consequently raises and lowers the acid level. This results in a violent agitation of the solution and not only does the acid chemically attack the scale on the sheets but this agitation mechanically helps to scour the sheet as well.

The plunging or Mesta type of sheet pickler, as illustrated in Fig. 1, consists of two or three wooden tanks rectangular in shape and so built that their length is tangent to a circle whose center is the vertical steam operated plunger. The tanks are constructed in a similar manner to the tanks used for the surging type being about 5 or 6 ft. wide, of sufficient length to hold sheets as long as 150 in. and deep enough to take care of the widest sheet rolled plus 2 or 3 ft. clearance for the up and down motion of the racks in the tanks. The first tank contains acid strong enough to remove the scale, the second tank also contains acid but much weaker (the use of the second pickling tank is optional) while the third tank contains rinse water which stops the action of the acid by removing the remaining acid from the sheets.

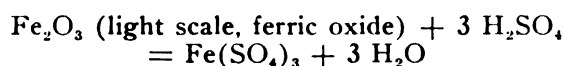
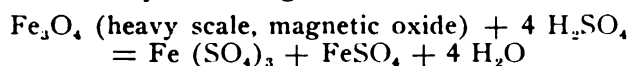
The sheets are placed edgewise in the rack or cradle which in turn is fastened by chains to one of the three or four arms extending out horizontally from the center plunger. The sheets are separated by vertical pins or grooves in the bottom of the rack which will hold from 100 to 120 sheets. Once loaded the rack is raised from the charging floor and the center plunger rotates thus swinging the rack over the first acid tank. The center plunger then drops about 6 or 7 ft. thus completely immersing the sheets in the acid. As soon as the plunger has dropped the sheets into the acid it is then caused to raise and lower this rack of sheets by means of two steam cylinders connected beneath the pickling floor to the main plunger. This plunging of the sheets continues until the sheets have been fully pickled and are free from scale. Meanwhile another rack is being loaded with sheets so that as the first rack is raised from the acid and swung over the second acid tank (optional) or rinse water tank the second rack is swung over the first acid tank and both racks are simultaneously dropped and plunged up and down in their respective tanks. Thus this process is made a continuous one providing that the acid tank or tanks are maintained constant in acid concentration and temperature and that the rinse tank has an intermittent, if not constant, change of rinse water.

Factors Concerning the Acid Solution

The concentration of the acid and the temperature at which the bath is maintained are the prime factors

to be considered. The acid content will range from 6 per cent to 10 per cent by weight and the temperature from 140 deg. F. to 180 deg. F. depending on the kind of scale to be removed. After the pickling of sheets has begun, the percentage of acid present will drop which means a proportionate increase in the pickling time as the solution absorbs iron salts (FeSO_4) and increases the specific gravity of the solution.

Chemically the changes are as follows:



These reactions are figured on the basis that the acid is attacking the scale only and in such a case no free hydrogen gas is evolved. However, this is not true on a commercial basis as the acid attacks not only the scale but the metallic skin and the basic metal as well with the excess acid over and above that used to attack the scale acting thus:



Hydrogen expressed as 2 H means that the atomic gas is in a nascent or free state and will combine with the first element capable of absorbing hydrogen which is near and in this case the iron sheet itself. Atomic hydrogen will penetrate into iron even at room temperature and it can readily be imagined that at the pickling temperature (around 160 deg. F.), it will be all the more readily absorbed. Furthermore, the small size of atomic hydrogen as compared to the molecular hydrogen ($4 \text{H} \rightleftharpoons 2 \text{H}_2$) is another factor affecting its rapid absorption. This absorption of molecular as well as atomic hydrogen at the temperature of the bath is satisfactorily explained, by an eminent authority on the processes of pickling, in that at this relatively high temperature there is a decrease in the rigidity of the crystalline structure of the steel and a slight opening of the space lattice.

Regardless of theory, the sheets do absorb a considerable amount of hydrogen which causes the sheets to become "blistered." Blowholes, seams and small cavities in the steel ingots may be only partially closed in rolling to sheet form and this hydrogen gas, if in sufficient quantity, getting into such cavities and pockets will expand these cavities causing the above mentioned blisters. If this "occluded hydrogen" does not raise the cavities and cause blisters it will cause an embrittlement of the steel and will often cause low spots on the stamping or local fractures. Microscopic examination of the fracture or low spot will often reveal cavities or seams which have become embrittled by the presence of hydrogen.

The only way occluded hydrogen can be removed from the sheet is by subsequent annealing and in some cases immersing in water but for automobile sheets the former is about the only practical method. Blisters, as found in the surface of automobile body stampings, can be traced to either faulty pickling or open hearth practice only after a thorough microscopic examination of the blistered portion. To prevent blisters sheet mills use inhibitors, of many trade names and formulae, all of which tend to absorb this hydrogen gas as quickly as it forms. Inhibitors are useful not only in preventing hydrogen evolution but

to retard the action of the acid thus preventing a "pitting" of the base metal. An excessive amount of acid will tend to eat into the softer elements making up the base metal of the sheet which results in a pitted condition. Inhibitors furthermore form a heavy dross or surface scum on the top of the bath preventing excessive evaporation of the acid and the presence of obnoxious fumes.

Regulation of the Solution, Rinsing and Scrubbing

The strength of the acid and the temperature of the bath are regulated in modern sheet mills by periodic tests. In the case of the acid concentration this is checked, say every hour or less, by the titration of a definite amount of the acid solution against a known basic solution such as sodium hydroxide which neutralizes the acid. The point of neutralization is noted by the change in color of the solution which contains a drop or two of an organic indicator such as methyl orange. Instead of using a liquid basic solution, capsules of known basic strength such as one capsule equaling 1 per cent of the acid present can be used thus speeding up the determination. Testing the specific gravity by hydrometer tests can be used but this is not as satisfactory.

The temperature of the bath is constantly maintained by live steam introduced through bronze pipes into the bottom of the acid tank and is thermostatically controlled so that the steam is admitted or cut off as needed. Recording charts indicate the temperature at all times.

The methods of rinsing vary only slightly in the various sheet mills. Following the cleansing in the acid tank the rack of sheets is then swung over a tank of cold water which removes the remaining acid. Following this rinse, full finished sheets are usually sent through a scrubber which removes on cloth rolls or soft brushes, the black deposit of carbon not attacked by the acid.

A large amount of this black deposit denotes over-pickling but as a general rule this runs as a very slight deposit on low carbon sheets. This light deposit requires very little effort to remove if sent through these scrubbers and followed by a spray rinse of water and then dried free from water by squeezing between rolls or in a similar manner.

Cold Rolling

Cold rolling is necessary in order to smooth out the sheets and at the same time give them a lustrous surface. Furthermore, it imparts a definite amount of stiffness which is necessary for certain automobile body parts. This stiffness increases with the number of passes through the rolls and each pass slightly decreases the thickness of the sheet with a corresponding increase in its length. However, we are usually interested in maintaining as soft a sheet as possible and in this event the sheets carry the minimum amount of cold rolling providing the surface is up to that desired. The slight decrease in thickness and the increase in length, as just mentioned, is not enough to be seriously considered due to the large surface area being rolled.

Cold rolling is carried out on a train of two high, non-reversing rolls which are constructed, arranged and set-up similar to a train of hot mill rolls described in a previous issue of this magazine. If four or more rolls are in line the driving power is set in the middle

of the train thus lessening the torque on the main drive shaft. In a sheet mill the line of cold rolls are usually in a separate department and so located as to be convenient to both the annealing and pickling departments. This arrangement reduces to a minimum the amount of handling of the sheets between these departments as most automobile sheets receive one or more cold roll passes after pickling or annealing or vice versa depending on their ultimate use.

The cold rolls are chilled cast in a similar manner to hot mill rolls with the outer surface of the roll having a hard small grained structure to a depth of $\frac{7}{8}$ to $1\frac{1}{4}$ in. which, after polishing with polishing blocks of fine mesh, give a smooth bright lustre to the sheet. In dressing down these rolls they are tapered or chamfered back from the end toward the center which helps to prevent spalling of the rolls occurring as they are screwed down too tight. In addition, this chamfer allows for the expansion of the ends of the rolls brought about by an overheating of the necks which cause the ends to slightly puff or expand. Extreme care must be taken to prevent the necks from overheating by proper lubrication. However, in spite of lubrication the necks will sometimes overheat, the ends will "puff" and to the extent that not only will the chamfer be absorbed but will cause the middle to run hollow. To compensate for a hollow center a gas or oil burner is lighted under the middle of the bottom

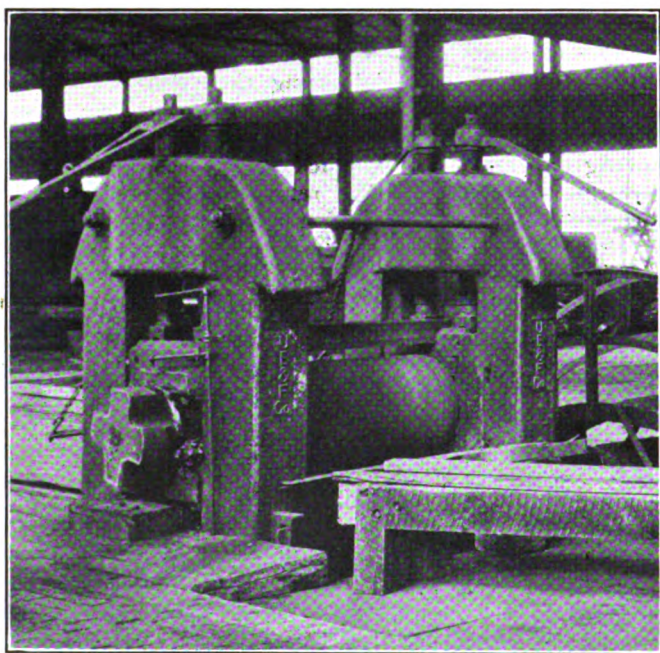


FIG. 2—Cold rolls set up for operating.

roll. If the cold rolls are running steady it is often necessary to keep this auxiliary burner on most of the time.

These cold rolls are set in housings each of which carries two screws in the top instead of one as in a hot mill housing. These two screws are placed on either side of the center line of the housing and thus bear down on each end of the top roll bearing. More pressure on one end of the bearing than on the other makes it possible to prevent any slight crossing or twisting of the rolls which could not be overcome by using side bearings. The two screws (one on each

housing) which are on the catcher's side of the rolls are usually set with heavy set screws while the other two screws (one for each housing) are fastened to a short lever bent so as to be easily adjusted from the feeder's side of the rolls. The short lever can be swung through about a 90 deg. angle which allows approximately a quarter-inch raise or spread of the top roll from that side only. This arrangement of screws, rolls and housings into which they set, is shown in Fig. 2.

Operation of Rolls

The feeding of sheets between cold rolls, while it seems simple, is without doubt one of the most exacting mechanical operations in the manufacture of sheet steel. The utmost care is necessary at all times to see that the rolls are properly adjusted, the rolls perfectly smooth and that the bearings are sufficiently lubricated.

Improper adjustment of the screws will result in a distortion of the sheet and an uneven pressure on its surface. Even if a sheet comes out of the rolls slightly curved at the ends, it will not matter as long as the entire surface has been given the same amount of pressure or "screw." A slight curvature of the ends can be easily overcome by roller leveling to be later described. Improper adjustment of the screws will cause more pressure on one end of the rolls than on the other resulting in one side of the sheet being convex while the other side is concave or what is known as a "cambered" sheet. This is remedied by a correct adjustment of the screws.

Rolls not kept free from loose dirt or defective sheets will result in a marking of the rolls and the subsequent marking of good sheets. This requires constant watching by the men operating the rolls and in some mills by men who report to the department which gives the sheets their final inspection before shipping. Loose dirt will often drop on the sheets which will be ground into the roll, thus pitting it. Sheets with bent corners and other imperfections, such as scale, must be bent into shape or cleaned of scale before they can be cold rolled. A marked roll means that it must be polished smooth before further rolling can be accomplished. A marked roll, if allowed to remain, will increase the markings by one forming another until the string of markings appear more and more pronounced on the sheet.

The polishing of the roll is accomplished by polishing blocks which are aided by the application of various light oils on the rolls such as palm oil or kerosene. A mill rolling a "dull finish" sheet is first dulled by the application of a weak solution of pickling acid which etches its surface. This is followed by a spraying of water on the rolls to remove the acid before the sheets are sent through them. The rolls are kept "in, round" and in a condition for high polishing by running them idle for several hours a day under a tight screwdown and sprayed with water.

Insufficient lubrication of the necks will result in the ends of the rolls overheating causing puffed ends, which in turn will often cause the mill to run "hollow." A hollow cold roll with puffed ends will cause a pinching of the sides of the sheet and possibly a buckling of the middle resulting in so called "pinchers," and in appearance are not unlike that of pinchers from hot mill rolls. As previously mentioned the puffed condition of the ends is overcome by sufficient

lubrication and the hollow center is remedied by the gas or oil burner under the middle of the bottom roll.

While roller leveling of the sheet is usually done in the inspection department in conjunction with oiling, some sheet mills, to lower operating costs, allow the sheet coming through to the catcher's side to be carried on to a roller leveler by means of a wide leather or canvas belt. Otherwise the sheets are piled by catchers and carried on to the annealing or pickling departments for subsequent treatment or if finished, to the final inspection department.

The order in which sheets are cold rolled is directly opposite that of the hot mills in that after polishing the widest widths of sheet are first sent through, followed by narrower widths as the rolls accumulate grease, dirt and markings from the sides of the sheets. Thus the widths are gradually cut down until it is necessary to repolish after which the widest widths available are again sent through and the procedure repeated.

Effects of Cold Rolling

As previously mentioned, cold rolling is primarily made on automobile sheets to produce a surface suitable for the part intended. The smoothing out and flattening are secondary to this feature. As we are interested in producing a sheet with the maximum amount of softness in order that the sheet may be drawn to shape with a minimum amount of breakage, there is as little cold rolling as possible. Each pass through the cold rolls decreases the softness and ductility and increases the ultimate tensile strength, elastic limit and hardness in proportion. Such facts then allow us to very closely control these properties by the amount of cold rolling. In forming automobile body parts we desire a maximum softness and a minimum hardness so possibly only one cold roll pass before inspection and roller leveling is necessary while sheets to be enameled and which will require very little forming may receive two or three cold rolling passes as its final operation of the process.

TABLE I

	Amount of cold rolling after anneal			
	None	1 pass	2 passes	3 passes
Ultimate tensile strength in lbs. per sq. in.	35,500	37,100	37,300	38,200
Elastic limit in lbs. per sq. in.	27,400	29,100	31,250	32,500
Per cent reduction of original cross area.	41	40	38.3	36.8
Per cent elongation in 8" ..	37	35	34	32
Per cent elongation in 2" ..	48	43	40	34
Hardness (Rockwell 1/16" ball—100 kg. weight) ..	34	35.5	40.5	45.5
Hardness (Brinell—500 lb. weight) ..	48	54	74	105
Ductility in inches (Olsen) ..	.385	.367	.360	.354
Ductility in millimeters (Erickson) ..	10.4	9.0	8.1	7.7

If the sheets are to be annealed the strength and stiffness imparted by cold rolling are lost but the surface finish is partially retained. Therefore, the sheets may receive one or more passes before the anneal and it can be readily imagined the combinations of pickling, cold rolling and annealing that are available which will give a sheet suitable for most any body part. Assuming, for the moment, that the sheet is to be cold rolled for its final treatment in

order to have a certain stiffness the proportionate increase in ultimate tensile strength, elastic limit and hardness and the decrease in ductility and softness is summarized in Table I. This table, while only approximate, shows, from a series of check tests, the proportionate physical changes which take place. Microscopically the structure is not appreciably distorted by this minimum amount of cold work put on auto sheets.

Motion Picture Film Depicts "The Story of Iron"

"The Story of Iron" is the title of a new educational motion picture film just produced by the United States Bureau of Mines, Department of Commerce, in co-operation with three large iron companies. The film depicts in a popular manner the processes involved in the mining and metallurgy of iron, which is styled the most useful of all the metals, due to its great strength, its adaptability to working, its abundance and low cost. Of the 130,000,000 tons of iron ore required annually for world consumption, the United States produces nearly half, it is pointed out.

The story of modern iron production begins with scenes depicting the methods used in prospecting for ore deposits. Panoramas are given of the great open pits in the northern Minnesota ranges, which illustrate the simplest and cheapest method of mining if the ore lies near the surface. Immense steam or electric shovels, weighing more than 400 tons, and with dippers holding 8 cu. yds., are seen stripping the overburden of dirt and rock. A view of the largest open-pit mine in the world is given. The methods of winning the deep-lying ore, which must be mined underground from a shaft or a tunnel, and methods of constructing mine shafts on the Minnesota ranges are also shown. Views are given of the top-slicing method, used in the mining of ore lying beneath rock or dirt that caves readily.

An interesting series of views shows the unloading of the long trains of ore at the Duluth docks, known as the largest iron-ore loading docks in the world. The transporting of the ore on the big boats which convey it down the Great Lakes to lower-lake ports for smelting, or for trans-shipment by rail to the blast furnaces of Pittsburgh, Youngstown and other centers, is shown.

Another interesting series of pictures shows the blast furnace in action, depicting the mixing of the iron ore with limestone and with coke. The tapping of the big furnace with an oxygen blow-pipe is depicted, and the molten iron is seen flowing from the furnace into the huge ladles by means of which it is handled. The methods formerly used in casting pig iron in sand beds are depicted, as are the more modern methods of casting by means of specially designed machines. A final scene shows the loading of the completed pig iron from stock piles for shipment.

Copies of "The Story of Iron" are available for distribution to schools, churches, clubs, scientific societies, and other bodies. No charge is made for the use of the films, although the exhibitor is asked to pay the costs of transportation. Information may be obtained by addressing the Graphic Section, Pittsburgh Experiment Station, United States Bureau of Mines, Pittsburgh, Pa.

The Effect of Coal Segregation, Mixing and Heating Upon the Quality of Metallurgical Coke*

Properties of Klondike Coals and Their Crushing and Preparation
—Separation that Takes Place in Passing Through the
Bunkers—Important Points to be Considered

By F. F. MARQUARD†

PART II

THE investigation as carried on by Clairton has been confined mainly to five different kinds of Klondike (Pittsburgh) coals. The following exhibit (Table A) shows analyses and yields of these coals and the chemical and physical properties of the coke produced.

Fuel value for Clairton coke is calculated as follows:

$$\text{Fuel value (quality index)} = \frac{\text{Strength} + \text{Hardness} - \text{Brittleness} \times (100 - \text{Ash})}{100}$$

To determine this fuel value from the barrel test a special revolving drum was made, the construction of which is 6 ft. in diameter and 2 ft. 8 in. wide and the drum is perforated with round holes 1½ in. in diameter and staggered on 2-in. centers; while there are five 6-in. angle bars or lifting bars fastened to the inside of the shell. The samples taken consist of 100 lbs. of coke, all of which passes through 4-in. square openings and remains on 2½-in. square wire screen; the 100 lbs. is put into the drum and the drum revolved for 50 revolutions at the rate of 13 revolutions per minute, and the quantities are screened and weighed.

The following calculations are made from the screen test of the coke after the test has been completed, which are used in determining the values which make up the fuel value of the coke:

- A = weight of coke on 2-in. screen left in the drum
- B = weight of coke through 2-in. screen left in the drum
- C = weight of coke on 1-in. screen which has passed through the drum
- D = weight of coke on ½-in. screen which has passed through the drum
- E = weight of coke through ½-in. screen which has passed through the drum
- F = dust loss
- G = total coke in drum (A + B)
- H = D + E + F
- K = 100 — G

$$\text{Strength} = \frac{100 \times A \times B}{C \times G} + G + \frac{C^2}{K}$$

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$$\text{Hardness} = 100 - H$$

$$\text{Brittleness} = C + D$$

$$\text{Fuel value} =$$

$$\frac{\text{Strength} + \text{Hardness} - \text{Brittleness} \times (100 - \text{Ash})}{100}$$

This is an empirical formula and is changed somewhat from the original to show a fuel value that more closely expresses the value we have found to be most desirable in the Clairton cokes for Carnegie furnaces. This seems complicated at first glance, but any test boy can run the test with a little practice in less time than he can make a shatter test. From this test we have been able to determine the relative quality of our furnace coke with a degree of accuracy as to its performance in blast furnace operation which heretofore was unknown. This type of formula and test for coke value was worked out by Moran & Thatcher, and adopted first as a standard test by the By-Product Coke Corporation at South Chicago and at Toledo Furnace Company. We have found this test so highly satisfactory for determining coke value that we have practically discarded the shatter and porosity tests.

Preparation of the Coals

Another important development in the Clairton coking of high-volatile coals has been found in the segregation of coarse and fines in the bunker. Much time and experimental work has been directed to the preparations of the coal before charging into the bunker. Most of the by-product coke plants of this country are using mixtures of low-volatile coals with high-volatile coals and in order to get a thorough mixture of these two greatly different coals it is necessary to crush the coals to very fine sizes, such as 80 per cent through ¼-in. screen and even 90 per cent through ⅛-in. screen; while others crush to 70 per cent through ⅛ in. or even as low as 65 per cent through ⅛ in. The range of preparation is limited to a fineness from 65 per cent through ⅛ in. to 90 per cent through ⅛ in. and various plants have usually found one size within this range which is best suited for their practice.

If, on the other hand, the coke plant is not using low-volatile coals in their mixture, it is apparent that there is no special reason to crush the coals to the degree of fineness used in the mixture, and in fact this is what has developed in the practice at Clairton, where 100 per cent high-volatile coals are exclusively used in their coking operations. Further, it has been determined that by not crushing the coals, we get a

TABLE A—Analysis, Yields and Tests of Various Kinds of Klondike Coal.

	Ronco	Gates	Palmer	Colonial	Bridgeport	*	Calumet
Daily consumption—net tons.....	4000	4800	8800	9600	2400		600
Analysis (dry):							
Moisture, per cent.....	3.12	3.53	3.60	3.62	3.37		3.84
Ash, per cent.....	7.89	8.65	9.18	8.87	10.00		8.85
Volatile matter, per cent.....	33.30	33.18	33.34	33.29	34.15		28.48
Fixed carbon, per cent.....	58.81	58.17	57.48	57.84	55.85		62.67
Organic sulphur, per cent.....	.64	.59	.60	.70	.64		.70
Pyrite sulphur, per cent.....	.49	.38	.65	.46	1.03		.54
Sulphur, per cent.....	.02	.02	.02	.02	.03		.03
Total sulphur, per cent.....	1.15	.99	1.27	1.18	1.70		1.27
Nitrogen, per cent.....	1.55	1.59	1.51	1.49	1.54		1.69
Chlorine, per cent.....	.13	.11	.11	.12	.08		.11
Pyridine solubility, per cent.....	28.56	21.30	28.03	28.25	28.00		18.00
Melting point, deg. C.	396	403	420	392	399		419
Yields per net ton (as charged):							
Total coke (2½ per cent H ₂ O), per cent.....	72.3	72.5	72.0	72.1	71.8		77.1
Tar, gals. (2 per cent H ₂ O).....	10.1	9.9	9.9	10.0	10.5		7.5
Amm. sulphate, lbs.	25.1	25.7	25.0	24.8	26.0		26.2
Water, total	8.4	8.7	8.7	8.6	8.5		9.9
Light oils, gals.	3.6	3.6	3.5	3.6	3.8		2.6
Gas cu. ft., 500 Btu.	12,670	12,600	12,680	12,690	12,750		12,100
Analysis of coke (dry):							
Sulphur, per cent.....	.80	.72	.90	.93	1.15	1.05	.90
Ash, per cent.....	10.66	11.56	11.75	11.75	12.50	12.20	11.50
Volatile matter, per cent.....	.35	.37	.37	.35	.38	.35	.35
Fixed carbon, per cent.....	88.99	88.07	87.88	87.90	87.12	87.45	88.15
†Physical tests of furnace coke:							
Screen test:							
Total on 3-in., per cent.....	22.3	22.7	23.2	21.5	25.5	25.0	24.0
Total on 2-in., per cent.....	73.7	73.6	73.9	72.5	74.4	75.0	76.5
Total on 1-in., per cent.....	98.5	98.2	98.2	98.3	98.3	98.4	98.5
Shatter test (old method):							
On 2-in., per cent.....	62.0	60.6	60.1	61.0	58.5	62.0	68.5
On 1-in., per cent.....	30.5	31.4	31.7	31.0	32.5	30.5	24.7
Barrel test:							
Strength	78.6	71.4	72.0	75.5	70.0	79.8	83.5
Hardness	77.6	75.6	75.0	77.0	73.5	78.3	79.0
Brittleness	47.7	52.1	52.0	49.0	53.5	47.0	45.0
Ash	10.6	11.5	11.8	11.7	12.5	12.2	11.5
Fuel value	97	84	84	91	79	98	104
Coking time, net hours.....	18.5	17.8	17.8	18.5	18.5	18.5	18.5

*Mixture of Bridgeport (67 per cent) and Calumet (33 per cent).

†Samples taken from the loading boom at the coke works.

larger weight per cubic foot, which is equivalent to compression, commonly used by European operators to improve the coke quality from 100 per cent high-volatile coal.

The Clairton method of preparing coal is to first classify it according to mines, then crush the large lumps to pass a 3½-in. screen; this gives us a coal of the following sieve test: 7.1 per cent on 2 in., 19.6 per cent on 1 in., 19.5 per cent on ½ in., 16.8 per cent on ¼ in., 14.0 per cent on ⅛ in., 23.0 per cent through ⅛ in.; and coal of this size will weigh about 51 lbs. per cubic foot compared to about 48 lbs. per cubic foot on coal crushed so that 80 per cent passes ⅛-in. screen. Thus we are able to get about 6 per cent more coal into an oven when using the coarsely prepared coal. Because of these and other advantages the tendency today, even with ovens using mixture of low-volatile coal, is to crush as coarsely as is possible without affecting the quality of the coke adversely.

But however carefully the coal has been prepared and mixed a very large separation again takes place when the coal is dropped into the coal bunkers, and the larger the bunker and the movement of the coal, the greater the separation of coarse and fines. Where there is a very large difference in the sizes, segregation of fine and coarse will be greatest.

In making a careful study of this phase of our operation, we arranged a series of distributing chutes to distribute the coal from the end of the shuttle conveyor over the entire surface of the bunker; these chutes helped to eliminate a portion of the separation of coarse and fines but the condition was far from satisfactory.

A further study of the elimination of this segregation of lumps and fines led me to conceive of the construction of our new coal bunkers with separate compartments from the delivery chutes to the outlet openings into the larry car, so that the coarse and fine coal would not have an opportunity to separate in its travel through the bunker, and would be drawn from the bottom practically the same as it is delivered into the top.

The following exhibit (Table B) shows the average screen tests and analysis of the coal as it is taken from the outlet at the bottom of a bunker without compartments as compared with the screen tests and analysis of coal taken from the bunker with separate compartments. The construction of the compartment bunker is shown in Fig. 2.

You will note that the coals on the coke side of No. 6 bunker show 2.6 per cent on 2-in. screen and 25.0 per cent through ⅛-in. screen, while the coal on

TABLE B—Showing the Distribution of Coal in No. 6 Bunker Compared with No. 8 Bunker—Sieve Test from Samples Taken from Each Row of Bunker Outlets.

Bunker No. 6—Palmer coal	On 2" %	On 1" %	On ¾" %	On ½" %	On ¼" %	On ⅛" %	Pan %	Weight per cu. ft. lb	Analysis		
									Moist. %	Sul. %	Ash %
Coke side, first row.....	12.4	22.2	7.7	10.5	15.4	12.2	19.6	50.8	2.60	1.65	11.80
Second row	9.5	16.4	8.0	11.0	18.1	14.2	22.8	51.0	2.90	1.46	9.97
Third row	4.0	22.2	8.4	10.4	16.2	14.2	24.6	50.5	3.20	1.28	10.61
Pusher side, fourth row....	2.6	17.6	9.4	12.4	17.4	15.6	25.0	50.6	2.80	1.30	10.53
Bunker No. 8—Palmer coal											
Coke side, first row.....	9.0	17.4	8.0	10.2	17.5	12.0	25.9	51.2	2.90	1.30	9.15
Second row	8.6	17.9	8.5	10.1	17.6	12.9	24.4	51.3	3.10	1.28	9.05
Third row	8.2	18.2	8.1	10.6	18.0	12.6	24.3	51.4	3.00	1.26	9.28
Pusher side, fourth row....	9.4	17.1	8.4	10.8	18.2	12.8	24.3	51.0	2.95	1.28	9.03

Samples from first row represent an average of samples taken from the six holes in this row; samples from second, third, and fourth rows taken in like manner. Bunker No. 6 is equipped with distributing chutes, but with no compartments. Bunker No. 8 is equipped with distributing chutes, with compartments.

the pusher side shows 12.4 per cent on 2-in. screen and 19.6 per cent through ⅛-in. screen, and not only is there a difference in the amount of the coarse and fines at the different outlets, but a material difference in the ash and sulphur content. The sulphur varies from 1.28 per cent to 1.65 per cent and the ash from 11.80 per cent to 9.97 per cent. This difference in size and analysis has always been looked upon as a disturbing influence in our coking operations.

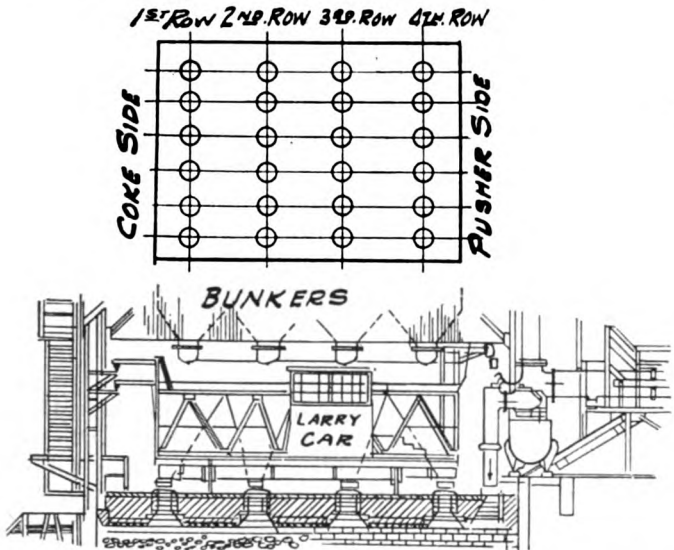


FIG. 2—Construction of compartment bunker. Upper sketch shows bottom outlets from 5,000-ton bunker for charging larry cars on top of ovens. Lower sketch shows larry taking charge from row of four outlets.

From Table B it is evident that this disturbing condition has been corrected by the new compartment bunker, for the variations in screen tests and analysis from different sections of the bunker are negligible.

The first bunkers of the compartment type that have ever been constructed were put into operation at Clairton in September, 1927. These bunkers have a capacity of 5,000 tons each and consist of 24 compartments each and surprising as it may seem a bunker of 24 compartments can be built at a cost no greater than a bunker without any compartments, due to the stiffening effect of the compartment reducing the heavy beam construction of the side walls, which otherwise would be necessary.

Finally to make good metallurgical coke from 100 per cent Pittsburgh high-volatile coal I wish to emphasize:

- 1—The importance of mixing only such coals coming from the same location which have about the same melting characteristics.
- 2—Removal of slate from the coal, not only for the purpose of lowering the ash in the coke, but primarily for removing a source of great harm in the coking quality of the coal.
- 3—The preparation of 100 per cent high-volatile coal to give maximum weight of coal per cubic foot; this gives larger oven capacity and best coke quality.
- 4—The construction of compartment bunkers to prevent segregation of coarse and fines in travel of coke through the bunker.
- 5—Uniform heating and the coking of these coals at very high temperatures, with a coke temperature of 2,075 deg. F. and over.
- 6—Efficient quenching with resulting moisture average of the furnace coke below 2½ per cent and very thorough screening and proper sizing of the coke.

Uniform coking condition gives uniform size of coke for each particular coal and this assists enormously in the furnace operation because of uniform carbon content per skip, and its effect upon the distribution and travel through the blast furnace.

The study of coals, with particular reference to their coking properties and the improvement in quality of the coke produced from them, is and should be a paramount subject in mining operations and the operation of the by-product coke plant. Much has been accomplished during the last few years which has encouraged us to continue our efforts towards the improvement of our coke quality. I wish at this time to mention the excellent research work and operating tests carried on at our Clairton by-product coke plant by B. M. Livezey, superintendent, and H. W. Seyler, chief chemist, and the co-operation of the Carnegie Steel Company blast furnace men in our efforts to establish a working index of coke quality.

Steel for Horse Shoes

Horse shoes are made of bar steel in two grades as follows:

- Bessemer—C.08/10, m.30/50, sul. limit .07
 - Open hearth—C.09, p.03, m.30/45, sul. .04
- The grades are the welding steel grades.

The Trend in Ingot Mold Design*

Variations from the Straight Sided Ingot—The Influence of the Shape of the Stool—Mold Life in Comparison with Resulting Steel Quality

By RALPH H. WATSON†

PART II

THE tendency in the shape of ingots is to abandon the straight sided ingot. A straight line cannot be deformed without stretching or breaking. Recent designs of ingots, therefore, are bulged or concave, corrugated or fluted. The rolling mill has again gone to the forge for its ingot. A few designs of rolling-mill ingot molds in present use are shown in Fig. 5. The present effort is to design an ingot with a long periphery. Quick-cooling longitudinal ribs are thought by some to strengthen the ingot in its early cooling stage. This is exactly opposite to the view that is held by those who strive for uniform cooling of the ingot. Their contention is that the good effect of these mold shapes comes entirely from the greater area, and therefore strength of surface. Mr. Radclyffe Furness, of the Midvale Company, related an incident out of his store of experience with molds that indicates that length of periphery, and a shape that will permit deformation in cooling is the vital point. A 31-in. square mold, with sides slightly concave and a corner radius of 2 in., repeatedly gave an ingot cracked longitudinally near the middle of the side. The mold was sent to the machine shop, and a notch or flute machined in the middle of the side as indicated by the full lines in Fig. 6. The mold from that time gave ingots without cracks. In this case the longitudinal rib would not strengthen the ingot materially against the forces cracking it vertically. The cure must have been the greater periphery. Fig. 7 shows a quarter-section of a 20-in. x 20-in. concave mold used at our Farrell Works. The mold and the ingot when cold were very carefully measured. Although the corner of the mold was considerably thinned, the ingot at the corner contracted away from the mold about 1/10 of an inch more than at the middle of the side. Although very slightly, the curve has straightened out somewhat, justifying the long and yielding periphery.

One of the most successful ingots, used by several makers of high-grade steel, is the 12-sided fluted ingot. It has the advantage of the yielding periphery, and if the quick cooling saliences do nothing more, they limit the length of horizontal cracks. Unless it is the result of a hanging ingot, a horizontal crack seldom extends beyond the corner. The 12-sided ingot limits the length of a crack to one-twelfth of the periphery, where a square ingot may allow it to extend to one-quarter. Fluted, concave and bulged ingots have the additional advantage over the flat ingot of a slight compression of the skin during the early passes in the mill, which is beneficial to the weak skin at that period. This is more marked if the ingot fits the pass and has collar support. For ordinary blooming mills,

the unequal-sided ingot is preferable to the square. The ingot should fit the first pass in the roll on its narrow side. The difference in length of side should be the reduction given before the first manipulation. In this way the ingot can be given collar support for all four sides in the first roll pass. This cannot be done with the square ingot.

Large and Small Ingots

Where a choice of a large and small mold can be made, the smaller will give the better quality of ingot.

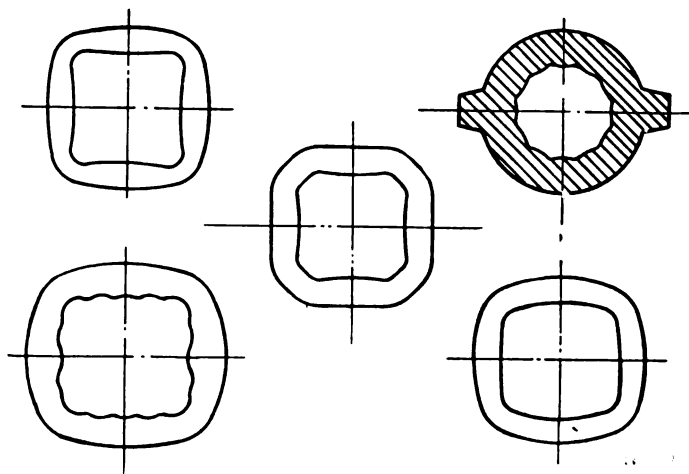


FIG. 5—Designs of rolling-mill ingot molds in present use.

While the larger ingot will not pipe deeper, the segregation will be greater. A curve plotted from the Report on the Heterogeneity of Steel Ingots, already referred to, shows that segregation increases with the mass of the ingot.

In no feature of mold design is there less agreement than on the point of corner radius. Radii vary in approximately the same-sized ingot from 1 in. to 6 in. and recently 8 in. From the standpoint of operations, there is considerable advantage in the large radius. Ingots pour with cleaner corners, cool more uniformly, and are in less danger of being burned in heating. The molds can be cleaned more easily, and are less likely to be neglected at the corners. The dendritic structure of the sharp-cornered ingot is well known. Columnar crystals, forming perpendicular to the mold wall, meet in a diagonal line of weakness. Inclusions are found entrapped by the meeting crystals. Forging ingots with sharp flutes are known to crack along the points of the flute or beneath the surface. On the other hand, advocates of the small radius point out that a round ingot is difficult to pour without cracks, and that an ingot with a large radius approaches the round. Molds that have produced vertically-cracked ingots have been corrected by decreasing the corner radius. The conflicting advantages and dis-

*Abstract of paper presented before the American Iron and Steel Institute, New York, May 25, 1928.

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advantages of the small and large corner radius indicate that both extremes should be avoided. There is a middle ground wide enough to allow considerable latitude, and it is not wise to correct the condition caused by one extreme by going to the other. A rule adopted by Mr. Morris, of Bethlehem, for rectangular molds, is to make the corner radius equal 13 per cent of the longest side, and for large molds somewhat less.

Design of the Stools

More attention is being paid the stools than heretofore. The contact with the mold is better, and they are equipped with guides to insure the mold sitting in the same position on the stool. A steel pourer, if he cannot trust the joint of his stool and mold, is apt

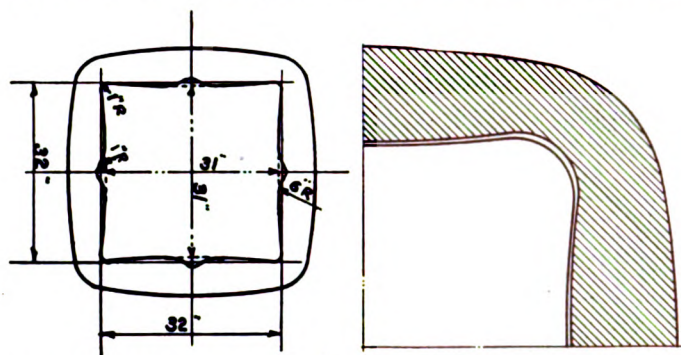


FIG. 6 (left)—Mold with notched side to prevent longitudinal cracks. FIG. 7 (right)—Quarter-section of concave mold (20 in. x 20 in.) used at Farrell Works.

to form the habit of opening up on each mold twice, the first time to test or seal the joint, the second time to pour his ingot. One splash is bad, two are unnecessary. Molds with curved bottoms are likely to be cut by the stream in pouring. To prevent this, the Penn Shenango Mold Company is now coating the core bottoms with a chrome coating that is retained in the mold, probably alloying to some extent with the iron.

Many big-end-down molds for blooming mill ingots have the dished stool. This makes a lighter bottom crop, and is said by some to lessen the likelihood of butt cracks. The butt crack is one of the most troublesome of ingot defects. It has been attributed to the dendritic cone caused by the chilling action of flat stools. This seems far-fetched as at best only the apex of the cone could be at the height of the crack, and so deep seated that the effect would be nil. It has been attributed to the splash, and the curved bottom of the big-end-up ingot is thought to correct it by minimizing the splash with the quick-forming pool. It is more prevalent in big-end-down than in big-end-up ingots. It is difficult to prove any theory that may be advanced for the formation of butt cracks, because when all favoring conditions are complied with the butt crack occurs in only a part of the ingots. Nevertheless there seems to be a more plausible explanation than any of those just given. During pouring, vertical contraction occurs at the bottom while the ingot is still in contact with the mold nearer the top. The ingot may be suspended, and if so will sometimes crack, or it may be held at the bottom by a horizontal fin between mold and stool. If the contact with the side of the mold is firm enough, this will surely crack the ingot, and the fin probably ac-

counts for the greater prevalence of butt cracks in the big-end-down mold than in the big-end-up where there is no bottom fin. Breaks through the skin due to hydrostatic pressure, if they occur, aggravate but are not the whole cause of this condition. An experience of the Firth Sterling Steel Company may be interpreted to confirm this explanation. In the small ingots, which they cast, they are not troubled with butt cracks. They experimented with a big-end-up mold with extremely heavy bottom and bottom walls. The bottom was closed and rounded as was usual in their molds. The ingots cast in this mold had butt cracks. The striking difference in this mold from others, which did not produce the butt cracked ingots, was the weight in the bottom and bottom wall. It seems likely that the quick chilling of the small ingot at the bottom caused rapid enough vertical shrinkage during pouring to suspend the ingot while the top was still in contact with the walls of the mold, and in this case the weight of the ingot cracked it.

Regarding the Life of Molds

Not too much consideration should be given to mold life. If it is achieved by keeping molds on the run too long, it is the poorest of economy. It must not be forgotten that a worn-out mold has a large salvage value. Mold cost less salvage varies from 1 per cent to 5 per cent of open-hearth conversion cost, depending upon type of mold, distance from source of supply, and other conditions. This means that the plant with the low mold cost can take only a one to a one hundred chance of scrapping an ingot with a worn-out mold, and the plant with the high cost only a one to twenty chance. Molds are not infrequently thrown off the run at the stripper. This is one heat too late, and the last heat is very costly. Where the product of the ingot must be chipped, chipping costs over-shadow the cost of molds. The records commonly kept of mold performance have been the life of the mold expressed in heats, and the pounds or cost per ton of ingots. Managers now are reading these records in a different light than formerly. Where a long mold life was commendable, it now immediately arouses suspicion when surface troubles develop.

In gathering this cursory view of the mold situation, little that is new has been brought to my attention. This does not mean that there has not been progress. On the contrary, we are in a period of rapid progress. It has come about by the better realization of the importance of the mold, by better workmanship and study at the mold foundries, and by the willingness of the steel plant manager to adapt his plant to meet new conditions. One cannot help being impressed, however, with the paucity of exact knowledge on many phases of the subject.

The variation in opinion and practice in different plants is too great, however, to be covered by the comforting phrase "plant conditions." Many are making more or less costly experiments with molds. There is much duplication of effort, and the field for study is so large that no investigation can cover it all. The mold is used again and again. The effect of the good and the bad in design is multiplied by the number of ingots cast. Could an improvement be made in the ingot through mold design, it might be multiplied by many millions, for more than ten million ingots are cast in iron molds in this country every year.

British Patents of Seamless Steel Tubing

This List Has Been Compiled as an Aid to Those Making a Study
of Manufacturing Processes, and to the Producer
of Steel in the Tubular Form

By VICTOR S. POLANSKY*

PART II

THE search for British patents is expedited by the Classified Abridgments issued by the patent office. The first series covers the years 1617-1883. The new series, with illustrations, runs from 1877 to date, the latest section issued covering patents through 1920. Class 83, part 4 is devoted to seamless steel tubing.

Prior to 1916, British patents were renumbered each year, and the date is thus necessary for identification.

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Mannesmann, Max. Improvements in Feeding Apparatus for Rolling Mills with Step by Step Action. (9,880 of 1905.)

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Mannesmann, Reinhard, and Mannesmann, Max. Improvement in the Manufacture of Rods, Tubes and the Like By Squirting, and Apparatus Therefor. (16,463 of 1902.)

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(Continued on page 925)

Basic Open-Hearth Practice*

Furnace Design and the Comparative Advantages of Tilting and Stationary Types—Importance of the Study of Slags and Slag Volumes—Means of Improving Steel Quality

By G. B. WATERHOUSE†
PART II

ANOTHER method to maintain supremacy is to pay the most careful attention to furnace design. This is constantly followed. Almost every time a furnace is rebuilt some change is made which it is hoped will improve its efficiency, speed up the time of operation, improve quality and reduce costs. The present tendency is to go to larger furnaces, particularly in the case of stationary furnaces, and experience has shown that quality has not suffered by growth in size of the heats. It would seem that, in regard to furnace design, the tilting or rolling furnace has not been sufficiently considered. This type of furnace offers many advantages. For certain modifications of the basic open-hearth process such as the Duplex process, or the Talbot process, it is practically indispensable. It is also very well suited for the ordinary process. A battery of such furnaces used for the production of ordinary and alloy steels, but principally of alloy steels, is shown in Fig. 2.

As against the use of the tilting furnace compared with the stationary, it must be admitted the cost of the furnace will be higher. This and other interesting material is brought out in Mr. Cort's paper‡ before the Institute. His nearest comparisons are between a 100-ton stationary, 650 square feet rated hearth area, tapping 140-ton heats, and a 200-ton tilting furnace, 675 square feet rated hearth area, tapping 225 tons of steel at each heat. He finds such stationary furnaces produce 13 to 17 tons of steel per 1,000 square feet of hearth area per hour, while the tilting furnaces will produce from 12 to 20 tons. The fuel ratio per ton of ingots he finds about the same, and the monthly production in the first case between 6,500 and 7,000 tons, but 9,000 tons in the second case.

	75-ton stationary	200-ton tilting
Weight of heat.....	82.8 tons	*2 of 107 tons
Average production per furnace per year.....	59,538 tons	110,639 tons
Tons produced per 1,000 sq. ft. per hour	13.9 tons	19.3 tons
Coal used per ton.....	587 lbs.	496 lbs.
Time of heats, tap to tap....	12 hrs. 7 min.	*8 hrs. 55 min.
Charge: Hot metal	49.89%	22.30%
Cold metal	1.73%	.15%
Steel scrap	42.84%	76.63%
Ore	4.11%	.01%
Bottom delays per furnace, per year	236 hrs. 9 min.	15 hrs. 10 min.

*Figured on single heats, as each ladleful carries a separate heat number.
†Paper read before the American Iron and Steel Institute, New York, May 25, 1928.
‡Professor of metallurgy, Massachusetts Institute of Technology.
‡Comparison of Open-Hearth Furnaces of Various Sizes, Stewart J. Cort, Yearbook, American Iron and Steel Institute, 1926, p. 149.

There is a very instructive table in his paper which is here reproduced, based on results obtained at an Eastern steel plant for the year 1925, which are more favorable to the tilting furnace than the above would indicate.
Based on the year's operation, the variation in the cost above net metal in the two cases is shown below in another small table, the stationary furnace practice being taken as the base.

	Variations in cost per ton of ingots, 200-ton tilting furnace
Fluxes	+ \$0.075
Heating	— .302
Total producing labor.....	— .151
Total repairs and supplies (labor and material)	— .171
Furnace rebuilding	— .183
All other expense.....	— .066
Total	— \$0.798

As Mr. Cort points out, the large furnace made a saving of 79.8 cents per ton on cost above net metal, which equals \$88,290 for the year per furnace.
He also gives a table of comparative construction costs, carefully worked out, and which would not be greatly changed today. The following is taken from it.

Furnace	Furnace with foundation	Waste heat boilers	Building	Total
100-ton stationary...	\$193,500	\$35,000	\$155,000	\$383,500
100-ton tilter	270,000	35,000	170,000	475,000
200-ton tilter	360,000	40,000	200,000	600,000
250-ton tilter	400,000	40,000	220,000	660,000

Notwithstanding this increased cost of furnace and plant, it is believed the tilting furnace offers advantages that offset the increased cost. Some have already been mentioned, and another of them is the ease of tapping steel. The finished material can be tapped into two or more ladles, thus obviating very large and expensive ladles and ladle cranes. Another very great advantage is the ability to remove all or part of the slag while melting, and be in position to make a new slag. In this way the furnace reactions can be carried on more rapidly, time can be saved, better steel made, the slag volume kept down and the fuel consumption kept low. Such advantages will be more appreciated when more attention is paid to slag volume and slag composition.
The sloping back wall, which is proving to be an outstanding improvement when applied to stationary furnaces is, and has been, an inherent part of tilting furnace design. With such furnaces there is very little if any delay due to tap holes and other delays between heats are very small. There is usually remarkable free-

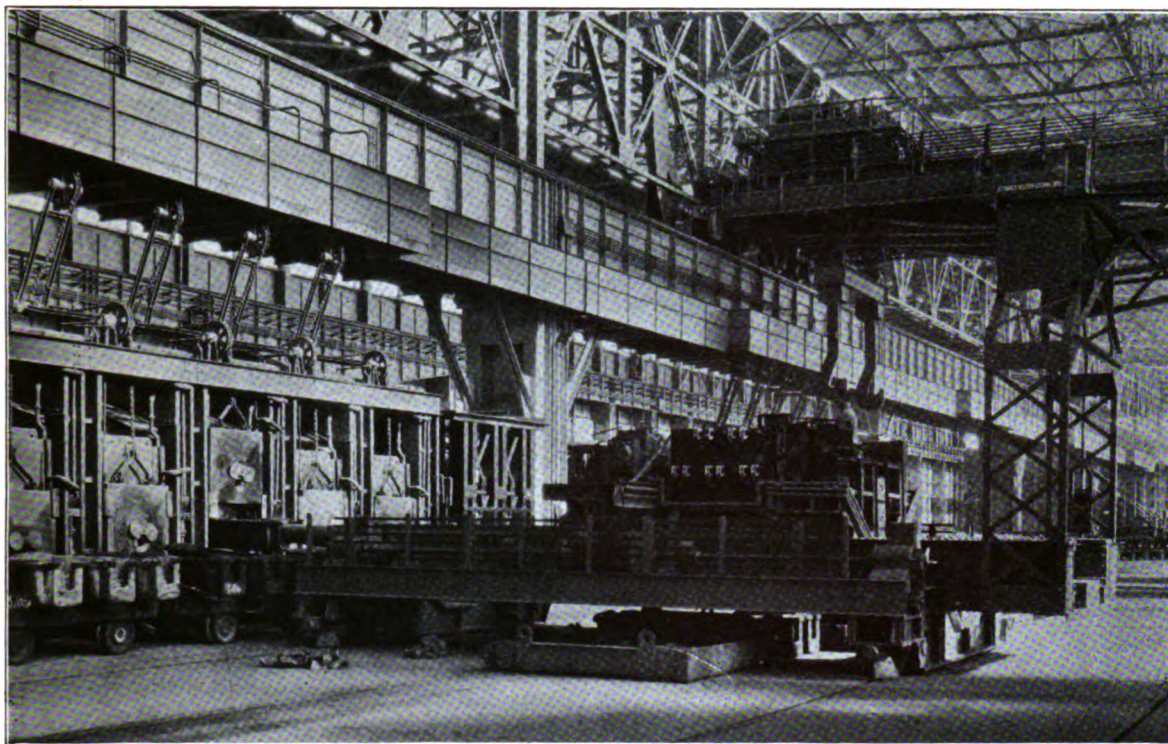


FIG. 2—Battery of seven 100-ton tilting furnaces, Ford Motor Company, Dearborn, Mich.

dom from bottom troubles, substantiated by the results given at the bottom of the first table reproduced from Mr. Cort's paper. The steel can be tapped clean and the slag held back in the furnace, thus doing away with the cases known in stationary practice where steel is harmed by slag coming before or with the steel. With such furnaces work is easier on the furnace crew and the men in the pit, and the general result is to speed up production, with the resultant effect on costs so well brought out in Mr. Cort's paper.

Study of Steel Making Reactions

One of the main ways in which the supremacy of the basic open-hearth process will be maintained will be by further study of the reactions that take place in steel making, the reactions in the slag, and the inter-reactions between slag and metal. All of these are profoundly affected by temperature and by the concentration of the various reagents in both slag and metal. It is now the custom to call this whole subject the physical chemistry of steel making, very properly so, for the reactions obey the laws of physical chemistry. This wide subject will provide a most fruitful subject for research for many years. It will undoubtedly show us how to make more steel in a given time, thereby reducing costs; and how to make better steel, thereby improving quality.

The importance of the slags in the steel-making processes is not yet fully recognized by the steel makers. It is true a first helper on an open-hearth soon learns that he must have a good slag if he is to have good steel, and he judges his slag by the way it lies in the furnace, and by the way it acts on the metal. Also he goes a good deal by the consistency, creaminess or liquidity, and an expert man also judges by the color. In rare cases a good melter or first helper will pour tests of the slag on to a clean floor plate and when cold will fracture the small cake, learning something from the color of the upper sur-

face and of the fracture. All the recent scientific work teaches and demonstrates that the question of slags is of the greatest importance, and it should be the effort of those interested in the basic open-hearth process to take every advantage of this information. Before many years, it is believed, regular tests will be taken of the slag during the working of the heat, sent to the laboratory and analyzed in similar ways to the steel samples. Such taking of samples from the steel bath is regular practice in most open-hearth plants and the furnace is not tapped until the steel has the right composition. When open-hearth men are agreed as to the prime importance of slag volume and composition, then systematic tests will be worked out by which the volume can be determined at any time during the working of the heat and the composition found out in regard to the elements or compounds that are important.

A start has been made in some plants by taking slag samples, pouring on a plate or granulating in water, crushing, removing steel particles with a magnet and determining metallic iron in the crushed slag by a quick method. This is usually done towards the end of the heat. One plant has made a rule that no heats be tapped until the iron is less than 18 per cent. This is to ensure that the slag shall not have too great an oxidizing power, which in turn means that the bath shall not be over-oxidized. The desired aim is reached in many of the ways familiar to open-hearth men, for instance, by not adding ore for a given period before tapping, so that the oxide of iron in the slag and bath may react with the impurities in the bath and the total oxide of iron be reduced to a low percentage. This total oxide will be distributed between bath and slag and equilibrium will be approached if sufficient time is given, the distribution depending mainly on relative volumes and temperature of bath and slag. Another method to reduce the total oxide of iron is to work an addition of cold pig iron or spiegeleisen

through the bath towards the end of the heat. Another effective means is to have a fairly high manganese charge and carry a high residual manganese in the bath, and on this topic a number of papers have been presented before the Institute.

Another element that could readily be determined in the slag is the manganese, and the results might be of value in estimating the slag volume. If the manganese in the charge were known, and no manganese had been lost in run-off slags, the determination of this element in both bath and slag might be of value, because we are learning a good deal about the laws governing distribution of manganese between bath and slag, and the effects brought about. Recently it was hoped a quick method could be worked up for determining the available lime in a slag sample, and thereby knowing whether the slag was deficient in lime. By available lime was meant the lime and magnesia not already combined or required for silica, phosphoric acid, etc., and so ready to do useful work. No quick, readily useful method was worked out, but it is not difficult to determine the total lime and magnesia and work is being continued with the hope that the results will be of value.

Slag Volumes

A fairly accurate method for determining slag volume would be of great value. All open-hearth men realize the need of keeping this as low as possible in order to speed up the transfer of heat from flame to metal, save fuel and increase production. On the other hand the volume must be great enough so that enough lime, oxide of iron, etc., may be present to carry on the reaction with the bath and to be sure that the impurities are not so concentrated in the slag that they are readily reduced back into the bath. The present tendency is often to carry too large a slag volume, as shown by the high percentage of limestone charged, so as to be on the safe side and help make the process fool-proof. When more experience is gained and slag tests are used more freely, it is believed the slag volume can be safely reduced, and as mentioned before, the tilting furnace would seem to offer an advantage in that low slag volumes could be carried, impure slags and those rich in impurities quickly and easily removed and new slags made again in relatively small volume.

Before leaving the question of slags a little will be said about run-off slags. This kind of slag has been mentioned earlier in the paper. It is quite common to take off such a slag especially when working with a high percentage of pig iron in the charge. With a pig iron running about silicon 1.20 per cent, manganese 1.15 per cent, phosphorus .165 per cent and sulphur .035 per cent, typical run-off and tapping slags would show:

This is with 57 per cent pig iron in the charge and about 10 per cent of limestone.

It will be noticed that the first slag removes from the furnace a great deal of iron and manganese, which is a disadvantage; but also removes considerable silica and phosphoric acid, which is helpful. It also reduces the subsequent slag volume and speeds up the time of the heat, which is an advantage. It is the custom now in many plants to send this slag to the blast furnace, particularly where the silica will not give too large a slag volume, so that much of the iron

	Run-off slag %	Tapping slag %
SiO ₂	24.10	14.22
Al ₂ O ₃	2.98	3.19
Fe	24.52	16.23
CaO	21.15	46.40
MgO	5.94	9.75
Mn	7.90	3.56
P ₂ O ₅	1.82	1.53

and manganese are recovered. It may again be pointed out that the tilting furnace would be very suitable for practice where a run-off or flush slag is thought advisable.

Improvement of Steel Quality

Another of the main methods by which the supremacy of the basic open-hearth process can be maintained is by the production of still better steel than at present, that is steel of improved quality. This calls for constant attention to metallurgical practice and increased care at every step of the process. For most of the steels made, it demands the greatest possible freedom from the non-metallic impurities, the "son-ims" of Mr. Hibbard's excellent paper* in 1919. To obtain the desired results special care is needed during the de-oxidizing period and the addition of recar-

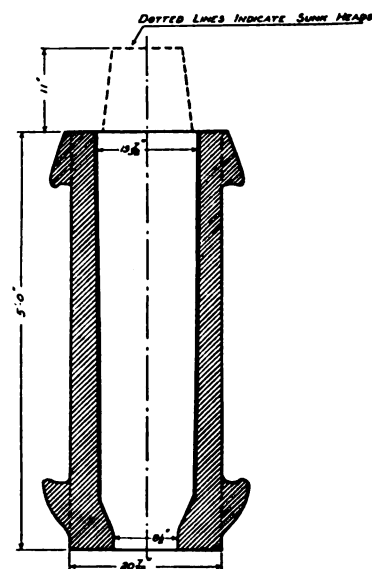


FIG. 3—Section of cast iron ingot mold.

burizers, etc., the handling in the ladle, the pouring and treatment in the ingot molds. Special care is necessary during pouring because the ingots should in most cases be sound and uniform, as free as possible from harmful segregation, pipe and other ingot defects. This calls for the handling of the steel from the time it leaves the furnace until the ingots are stripped by men of the same calibre as the furnacemen. Most steel plants make a mistake in not paying proper attention to this phase of the work. The man in charge of ladle practice and preparation, condition of molds and pouring should be of similar type to the open-hearth melters and fully alive to the great importance of his share in successful steel making.

*Present Knowledge Concerning Non-Metallic Impurities of Steel (Sonims), Henry D. Hibbard, Yearbook, American Iron and Steel Institute, 1919, p. 93.

Many experiments are still being made in methods of pouring. One of them may be described in some detail. It is that of the Ford Motor Company, Dearborn, Mich., where alloy steels are mostly made. The pouring practice is a modification of the basket pouring used in many of our plants during the war. The ingots are small, weighing 1,700 lbs., so as to cool quickly and lessen segregation. They are cast big-end-up in an inverted mold, each mold being provided with a hot top. The cast iron molds are 60 in. high and of the shape and other dimensions shown in Fig. 3. The interior of the molds in cross section is a corrugated ellipse, and they stand eight on a stool. The bottom of the molds is closed with a $\frac{1}{8}$ -in. steel pan, $8\frac{1}{2}$ in. diameter and $1\frac{1}{4}$ in. high, which gives a clean bottom. On the top of each mold is placed a sand hot top made at one end of the open-hearth pit from ordinary reclaimed foundry sand and a binder. The molding is done on a machine and the tops are thoroughly dried at 500 deg. F. in a continuous core oven. The molds are scraped and brushed between heats then dipped in a graphite wash.

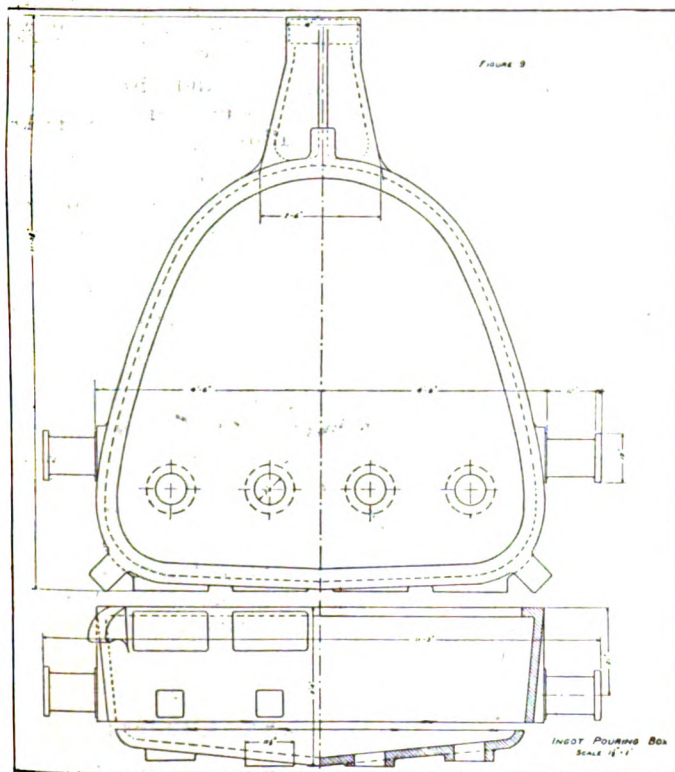


FIG. 4—Plan and section of ingot pouring box.

The pouring box or basin is shown in Fig. 4. It is roughly triangular in shape, provided with four $1\frac{3}{4}$ in. nozzles with stoppers near the base of the triangle, set on 24-in. centers. This device is mounted on a movable carriage, so that the stoppers can be accurately centered over the four molds on one side or the other of the car. The box is lined with firebrick and has a cover, also lined with brick. There are four slots in the cover through which the stopper rods extend, and at the other end of the cover is a rectangular opening 5 ft. $\times$ 1 ft. through which the steel is poured from the large ladle. Two steel pourers operate the stoppers. When the four molds on one side are filled the nozzles are closed and the box moved electrically on its carriage 39 in. over the other four molds. When

these are filled, the cars are moved by a car-pusher and the next car brought mechanically into position. The large ladle is not moved. The number of ingots per heat varies from 115 to 130; they appear very clean when stripped, and cut-open ingots are very sound and need very little discard to be free from pipe.

Electric Towboat for Transporting Steel

An electric towboat, for use in transporting steel products along the Warrior River in Alabama, is now being built for the Tennessee Coal, Iron & Railroad Company of Birmingham, Ala. The new boat will be of the tunnel stern, twin-screw wheel type and will be propelled by Diesel-electric drive.

The boat is being built by the American Bridge Company and will be outfitted by the Carnegie Steel Company, both of Pittsburgh, Pa. The electric equipment will be furnished by the General Electric Company. The Tennessee Coal, Iron & Railroad Company has several steam boats of the stern paddlewheel type in operation, but Diesel-electric drive was adopted for the new boat in order to obtain higher efficiency and better maneuvering qualities. The Warrior River is a tortuous one, having many sharp bends, and is relatively shallow with swift currents. The length of tow is limited to seven barges by certain bends in the river. These barges will be pushed ahead by the towboat.

The towboat will be completely electrically equipped, with the exception of the galley and the heating facilities, the latter being provided by a small donkey boiler.

British Patents of Seamless Steel Tubing

(Continued from page 921)

Wikström, Malcolm Urban. Improvements Relating to Piercing Mills for Producing Metal Tubes. (17,379 of 1909.)

Williams, Charles Francis, and Dicks, William. Improvements in or Relating to the Production or Manufacture of Seamless Metal Tubes. (26,467 of 1906.)

Winter, Emil. Improvements in Apparatus for Rolling Tubes and Other Articles. (16,594 of 1906.)

Winter, Emil. Improvements in Tube and Other Rolling Mills. (9,013 of 1907.)

Wolffgram, Ludwig. Improvements in Rolling Mills for Seamless Tubes. (145,418.)

Wolffgram, Ludwig. Improvements in Seamless Tube Rolling Mills. (145,092.)

Wootton, Robert. Improvements in Machinery for the Manufacture of Seamless Steel Tubes. (5,478 of 1895.)

Wootton, Robert, and Goold, Lewis William. Improvements in the Manufacture of Metal Tubes and in the Machinery for the Said Manufacture. (12,270 of 1894.)

Wotherspoon, John. Improvements in and Relating to the Turning and Feeding Mechanism Used in the Step-by-Step Process of Rolling Tubular Blanks. (14,070 of 1897.)

Wüstenhöfer, Julius, and Surmann, Wilhelm. Process for Producing Weldless Hollow Objects (Tubes) Direct from a Solid Block. (24 of 1893.)

The Making of Steel Castings in 1927

A Brief Enumeration of Manufacturing Processes, Chemical Composition and Properties—Co-operation Between Consumer and Maker Urged—Heat Treating Enhances Service of Castings

By FRANK HODSON*

THE tendency in 1927 was closer attention being given to the use of the correct steels for specific purposes and the increasing use of alloy and heat treated steel castings. Electric steel castings continue to increase in popularity while those made by the crucible Bessemer process are gradually becoming less. Open hearth steel is still largely used for the cheaper grades and for very large castings, but even that is being challenged by electrically made material. The electric furnace process has a much wider range and is under better scientific control than any other method of steel making, and it is the only one that can handle some of the complex alloys now demanded.

Formerly a steel casting meant anything with a steel base and it was bought as cheaply as possible. Nowadays buyers and users are realizing the service life of a steel casting is the chief thing to be taken into consideration, and the price secondary.

Considerable work has been done in the last few years in improving ordinary carbon steel castings by better control and care in manufacture and by correct heat treatment afterwards. Unfortunately the general tendency of the buyer is to place more reliance on the machinability of a casting than on its correct heat treatment after machining and consequent service life. Steel castings are frequently put to work exactly in the same soft annealed state as shipped from the manufacturer's plant, whereas a very simple heat treatment after the machine work has been done would increase their useful properties 50 per cent.

Users of steel castings can benefit more than they imagine by taking the steel manufacturer into their confidence as to the design and actual conditions under which the castings will operate. In the majority of cases—assuming the steel foundries have metallurgists who know their business—it will result in lighter total weights, less breakdowns and longer service life.

Alloy Steel Castings

The use of alloy steel castings containing varying percentages of manganese, chromium, nickel, molybdenum and vanadium is as yet in its infancy although the yearly tonnages of such materials is increasing rapidly.

Many of these alloy steel castings, although containing only small percentages of one or other of the elements mentioned, can by correct heat treatment after machining, be made capable of withstanding extremely severe operating conditions. Thus if a steel is required with intense hardness a small addition of chromium will give that property and at the same time retain toughness. The relationship between hardness and toughness can be regulated to a nicety by the carbon content and by the heat treatment. For refinements of the properties of hardness, toughness, resistance to abrasion, shock, impact, ductility, nickel and vanadium may also be added.

*President, The Empire Steel Casting Co., Reading, Pa.

The high manganese steel castings (10 to 14 per cent) have a very wide and useful field where resistance to abrasion and great toughness is required, but it has the disadvantage of tending to flatten out or flow under continued pressure. For this reason other simpler alloy steels are now being used, which under correct heat treatment, give much more satisfactory results.

Manganese and Nickel Castings

Some of the lower percentage manganese and manganese-nickel steel castings have remarkable properties under heavy steam or liquid pressures and are cheaper and simpler to handle than the high manganese steels. They are also used to replace forgings of complicated design, being cheaper, lighter in weight and with better physical properties.

The use of high chromium and chromium nickel castings usually with over 18 per cent of chrome, is extending rapidly. These alloys have remarkable resistance to heat and corrosion, and at the same time have a strength and toughness even under extreme conditions.

Fortunately for the metallurgist the various alloying elements impart clearly defined properties to steel, and their behavior under most conditions is known. However, no two different designs of steel castings are called upon to do identical work or to withstand identical stresses, so the buyer and user of castings will appreciate the advisability of having his work done by a concern who first, know their steel, what is expected of it in service, and can tell him how to get the best results from it.

If the casting manufacturer could always do the machining and heat treatment in his own shop, the solution would be easier, but existing conditions generally prevent this possibility.

Slag Association Elects Officers

At the eleventh annual meeting of the National Slag Association which was held at the offices of the association at 937 Leader Building, Cleveland, Ohio, June 8, 1928, the following officers were re-elected for the ensuing year: C. L. McKenzie, Duquesne Slag Products Company, Pittsburgh Pa., president; C. E. Ireland, Birmingham Slag Company, Birmingham, Ala., vice president; H. J. Love, 937 Leader Building, Cleveland, Ohio, secretary-treasurer.

Metal Furniture

Metal furniture in composition houses will make the American home of the future, according to the prediction of Lee Simonson, modernist designer and architect, who spoke at the opening of the recent International Exposition of Art in Industry, held in the exhibition galleries of R. H. Macy & Company.

The POWER PLANT

Firing of Gas and Pulverized Coal*

Engineers Burning or Contemplating Burning These Fuels Will
Find Information in This Paper of Much Practical Value
—Results Are Authoritative and Representative

By F. G. CUTLER†

THE Ensley blast-furnace plant of the Tennessee Coal, Iron & Railroad Company, consisting of six blast furnaces, has been operating for about five years a boiler plant using pulverized coal to supplement blast-furnace-gas firing, and some of the results obtained from this installation should be interesting to those contemplating combination firing of these fuels.

Prior to 1922 the No. 1 boiler plant near No. 1 furnace consisted of 22 Rust boilers and 8 Stirling boilers with a total of 18,000 rated horsepower. At No. 2 boiler plant between No. 5 and No. 6 furnaces were located 24 Wickes boilers, the total rated capacity of this installation being 6,520 bhp.

These boiler plants were interconnected and steam was supplied from these plants to No. 1 power house near No. 1 steam plant and through two steam lines to the blooming mill and rail mill. This mill also had a boiler plant consisting of 5 Stirling boilers and 17 Cahall boilers with a rated capacity of 6,750 bhp. Coal was fired by hand on grates under the Rust boilers at No. 1 plant and the Cahall boilers at the mill, and by underfeed stokers on the Stirling boilers at the mill.

Steam conditions were unsatisfactory. Some of the older blast-furnace boilers were in such condition that it was expected that they would be condemned, and their combustion capacity was insufficient for the proper burning of the blast-furnace gas available most of the time.

After investigation of a number of plans for improvement, it was decided to install additional boilers adjacent to the Rust boilers at No. 1 plant and to fire them with blast-furnace gas and pulverized coal in the same combustion chamber.

Six Stirling boilers of 834 rated bhp. each were installed. These were built for 250 lb. per square inch working pressure and 150 deg. of superheat. Each boiler was equipped with blast-furnace gas and pulverized-coal burners. A pulverized-coal plant, located about 500 ft. away from the boiler house, supplies this plant with powdered coal. This plant was described in several technical magazines‡ the first boilers being fired with gas in September, 1922, and with pulverized coal in February, 1923.

The Cahall boilers at the mill were removed from service shortly after this plant was put in operation.

*Paper presented at spring meeting of A.S.M.E., Pittsburgh, Pa., May 14, 1928.

†Chief of Bureau of Steam Engineering, Tenn. Coal, Iron & R. R. Co. Mem. A.S.M.E.

‡See "Power," November 6, 1923.

and a 5,000-hp. geared motor replaced the steam engine driving the rail-mill rolls.

Two additional powdered-coal and blast-furnace-gas-fired boilers were installed in 1925, the boilers and equipment practically duplicating those installed in 1922, except for minor changes in the setting. Additional gas-fired boilers replaced the older boilers at No. 1 plant, and as the additional gas-burning capacity at No. 1 steam plant was made available, some of the boilers at No. 2 steam plant were taken out of service.

Boiler Setting

A cross-section of the setting showing the latest boilers installed is found in Fig. 1.

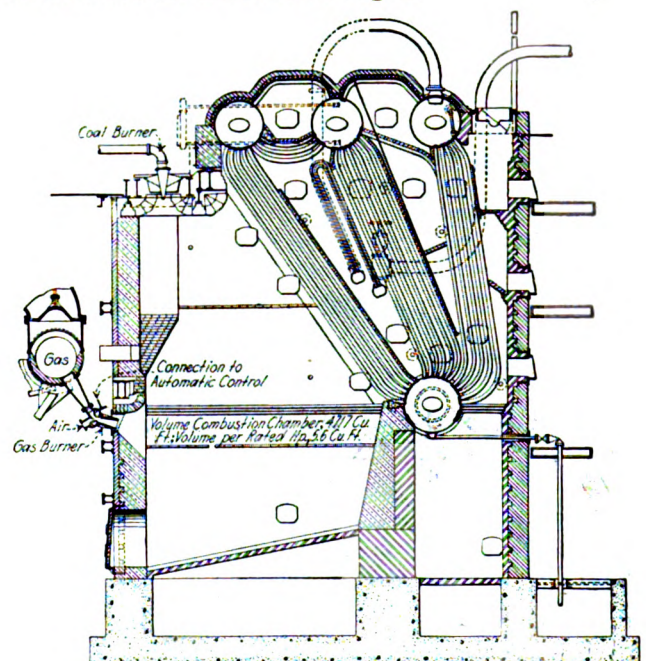


FIG. 1—Cross-section of boiler setting.

These boilers are arranged to be fired with either blast-furnace gas or pulverized coal, or a combination of both fuels at the same time, and are also equipped with gas regulating equipment which operates to open the gas and interconnected air dampers whenever the gas pressure on the mains increases and to close whenever the pressure falls. The gas burners were initially supplied with air from the fans supplying primary air to the coal burners, but it was found that this was not

necessary, and connection was eliminated from the gas burners as it was found that sufficient air for proper combustion was induced by the gas flow.

By regulating the supply of gas to these boilers the supply to the hot-blast stoves and remaining gas-

The gas supply has major fluctuations due to the fact that one or more furnaces may be out of service or shut down for casting or temporary repairs, and minor fluctuations due to rate of driving, stove changes, and

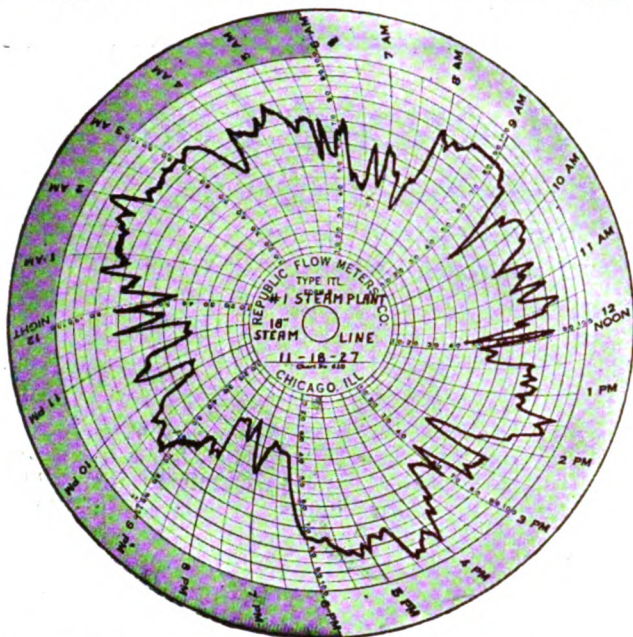


FIG. 2—Steam flow in 18-in. line supplying No. 1 power house.

fired boilers is equalized, thereby reducing the demand for regulation of gas and air supply on these units.

The powdered-coal feeders on these eight boilers are under the control of a regulator by means of a system of shafts, cables, and other devices which varies the position of levers on the rheostats controlling the speed of the feeder motors. The dampers of the boilers are controlled by regulators to maintain approximately a balanced-draft condition in the combustion chamber.

In a blast-furnace boiler plant steam conditions are affected by the supply of gas and by the demand.

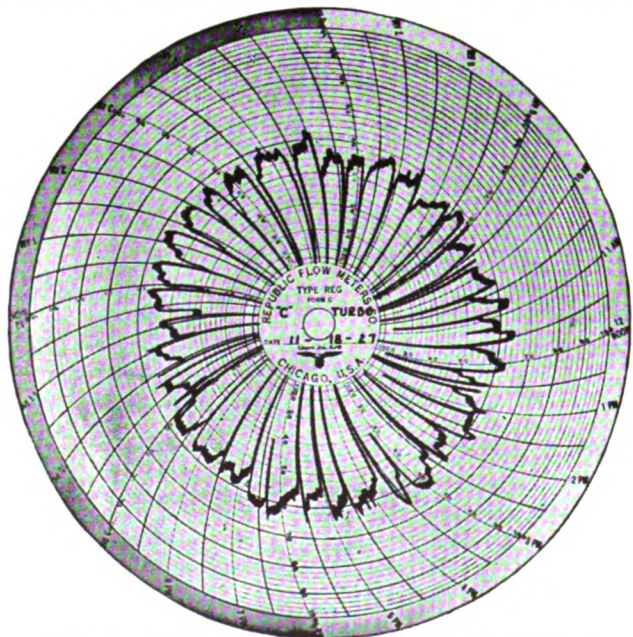


FIG. 3—Steam flow in 12-in. line supplying high-pressure turbo-blower.

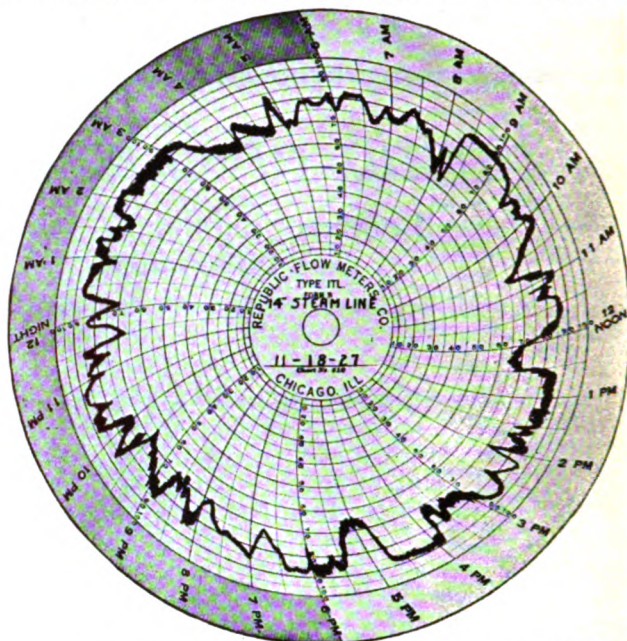


FIG. 4—Steam flow in 14-in. line supplying mills and No. 2 power house.

similar causes. The steam demand for blast furnaces, mills, and electric power varies widely, and there is usually very little notice of these variations given to the boiler plant.

In order to show the extent of these variations, a typical set of charts for the period ending at 6 P.M. on November 18, 1927, is presented with a brief discussion.

Fig. 2 shows the steam flow in the 18-in. line supplying No. 1 power house, any steam not used by the No. 1 power house being delivered to the steam lines supplying the mills and No. 2 power house. This chart indicates a variation in demand from this service from

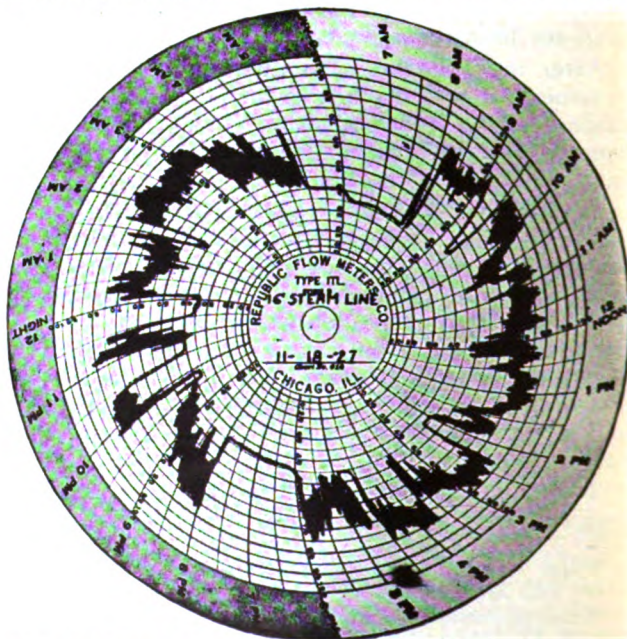


FIG. 5—Steam flow in 16-in. line supplying mill engines.

about 2,800 bhp. to over 10,000 bhp., although the average for this 24 hours was 6,740 bhp.

Fig. 3 shows the steam flow in a 12-in. line supplying a high-pressure turbo-blower, also supplied from this plant, indicating a variation in demand for the same day of from 200 to 2,450 bhp., averaging 2,160 bhp. Other uses, including turbo auxiliaries, require a steady load, estimated at about 800 bhp. so that the steam demand on these boilers varied for this particular day from about 5,000 to about 12,000, averaging 9,700 bhp. As there were 7 boilers in service, each rated at 834 bhp., the demand varied from about 80 to 200 per cent of rating, although the average was about 166 per cent. Individual boilers have delivered 2,000 bhp. for short periods, or about 240 per cent of rating. This latter rate of operation, if continued, causes slagging of blast-furnace flue dirt and powdered coal ash.

Fig. 4 shows the flow in a 14-in. steam line supplying the mills and No. 2 power house.

Fig. 5 shows the flow in a 16-in. steam line supplying mill engines.

Operating Results

A summary of the operating conditions for the 24-hour period covered by these steam-flow charts is given in Table I.

TABLE I—Summary of Operating Conditions.

	Average 24-hr. period	Maximum load on powd.-coal boilers	Mini- mum load, no coal
Steam generated from coal on powdered-coal boilers, bhp.....	3,490	11,000	.....
Steam generated from gas on powdered-coal boilers, bhp.....	6,210	1,000	5,000
Steam generated, total on powdered-coal boilers, bhp.	9,700	12,000	5,000
Steam generated on other furnace boiler, bhp.	31,020	32,000	30,000
Steam generated, total blast furnaces, bhp.	40,720	44,000	35,000
Percentage of total blast-furnace steam made from coal	8.6	25	0
Average bhp. per boiler, powdered-coal boilers	1,385	1,715	715
Estimated efficiency, powdered-coal boilers, per cent	73	72	75
Rating, powdered-coal boilers, per cent	166	206	86
Btu. per hr. per cu. ft. of clean combustion-chamber vol.	13,460	16,900	6,780

2000 bhp. with 71 per cent overall efficiency corresponds to about 20,000 Btu. liberated per cu. ft. of clean combustion-chamber volume.

Flue dirt and ash accumulate in the combustion chamber between cleaning periods so that when the boiler is taken out of service for cleaning, the combustion-chamber volume is reduced from 20 to 25 per cent, and it is not possible to deliver above about 1,500 bhp. per boiler without the formation of slag in the combustion chamber.

Fig. 6 shows the steam pressure for November 18, and Fig. 7 shows the blast-furnace gas pressure on the mains for this 24-hour period.

Low steam pressure noted at 3:50 P. M. and 4:15 P. M. and 12:45 A. M. corresponds to high steam demand for electric power and for the mills, with low

gas pressure at the same time, and during these periods pulverized coal was burned to capacity. The pulverized-coal burners cut out at about 170 lb. per square inch and the safety valves blow at about 180 lb. per square inch, so that on this day coal was being

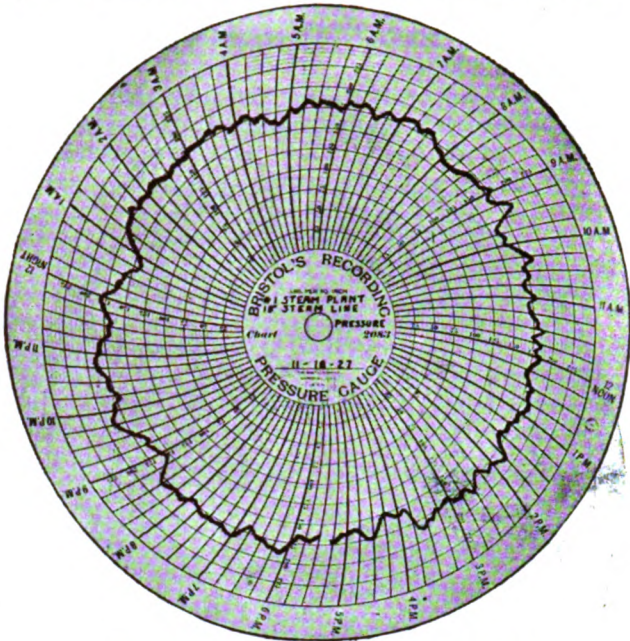


FIG. 6—Steam pressure on day of tests.

burned for 17 periods for a total of about 10 hours, the periods of coal burning varying from 2 to 95 minutes. About 150 net tons of pulverized coal were burned for this 24-hour period, at the average rate of 30,000 lb. per hour during the firing period. During some of these periods coal was burned at an estimated rate of over 40,000 lb. per hour and the gas supply was nearly all cut off of these particular boilers.

To generate 9,700 bhp. with coal having 12,500 Btu. per pound with boilers averaging 75 per cent efficiency would require 415 net tons of coal per 24 hours, so that about 36 per cent of the steam generated on these particular boilers was made from coal and 64 per cent from gas.

However, the other blast-furnace boilers in service during this 24-hour period generated an average of 31,020 bhp., so that for the whole blast-furnace plant only about 8.6 per cent of the steam was generated from coal and 91.4 per cent from gas. During the periods when pulverized coal was fired to capacity about one-fourth of the steam was generated from coal.

Handling Coal

About 20 kw. is required to pulverize and deliver coal to the bins at the boilers and about 1,200 cu. ft. of by-product gas is required to dry the coal, per ton of coal. Usually the coal is dried to under 1/2 per cent of moisture, although the moisture in the coal as received is at times between 7 per cent and 8 per cent.

There has been no trouble experienced in pumping the coal through the 625 ft. of 4-in. line, which is the only means of supplying this plant with powdered coal, and there has been no trouble with the feeders. Usually the bins are emptied when a boiler is taken out of service, but occasionally boilers have to be taken off with coal left in the bins, and on one occa-

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sion there was found (on resumption of operations) a deposit of partially burned coal in the feeders, indicating that the coal had fired in the bins, presumably by spontaneous combustion.

There have been two or three drier fires caused by overheated coal, or by pitch, which got into the coal by mistake, but the only damage done was limited to the drier-fan runner.

There has been little difficulty with the uncleaned, uncooled blast-furnace gas, except that during periods of high rates of operation it has been necessary to

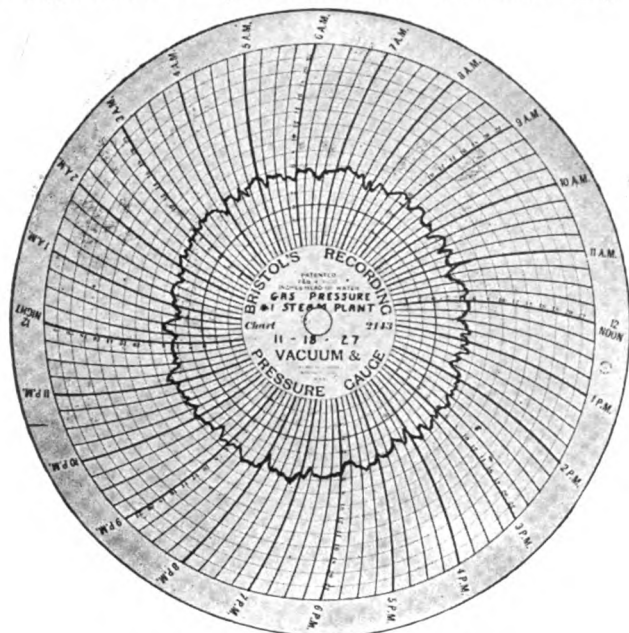


FIG. 7—Gas pressure on day of tests.

take the boilers out of service because the deposit of ash and flue dirt had accumulated almost to the level of the gas burners and sealed off the air supply in the lower portion of the combustion chamber.

Usually these boilers are taken out of service about once a month for washing, reaming, repairs, and to clean out this accumulation, and the usual practice is to take one of these boilers out of service when another is put on, one boiler out of the eight being off.

It has not been found practicable to measure with accuracy hot uncleaned blast-furnace gas, and as this fuel is the principal supply to these blast-furnace boilers, it is not possible to furnish definite figures as to efficiency.

Indirect heat-balance tests have been made from time to time and the efficiency is usually between 72 and 79 per cent, depending on rating.

Tests were also made with pulverized coal alone, these tests showing about 225 per cent of rating on capacity tests, and about 79 per cent efficiency at 179 per cent of rating. Both fuels are usually burned together, the ratio depending on gas and steam conditions.

Probably the best way to show the effect of this installation is to compare the conditions prior to when it was made with those after these boilers were in service.

The gas from the blast furnace is supplied to stoves to heat the blast and the remainder is delivered to the boilers. A regular, low pressure on the mains should reduce leakage, as well as improve the combustion ef-

iciency of the stoves. However, with uncleaned and uncooled gas it is not possible to operate stoves very efficiently, as the combustion-chamber temperature incident to efficient combustion fuses the small particles of flue dirt, resulting in slagged and clogged checkers, and making it necessary for the stoves to be taken off for cleaning at relatively frequent intervals.

Again, due to increase in blast requirements incident to a program of furnace enlargement, there have been periods when there was not sufficient stove capacity, and other periods when, due to adjacent furnaces out of blast or to new stoves in service, there was a temporary surplus of stoves on individual furnaces with a tendency to leave them on gas too long for efficient results.

Again, with mill or power demands for steam requiring all available surplus gas, there is usually a disposition on the part of the blast-furnace operators to be as economical in the use of gas as possible, as the sale of surplus steam produced from this gas reduces the net operating costs of the furnaces.

As these general conditions have not materially changed within the past 10 years, it is fair to assume that any increase in steam production from gas over a long period is due to improvement in the total combustion efficiency.

In a paper* presented at the Atlanta Spring Meeting of the A.S.M.E. in 1922, there was outlined a method of checking overall combustion efficiency of blast-furnace gas by calculating from the coke rate the heat in the top gas.

The total steam generated at a blast-furnace-gas-fired plant is obtained by means of venturi feed-meter readings with suitable allowance for blow-off losses, and the total coal burned is obtained by car weights, so that it is possible to approximate closely the steam generated by furnace gas by subtracting the steam made from coal from the total.

TABLE II—Comparison of Ensley Plant for Nine Yearly Periods

Year	Average bhp. generated—			Coke per ton of product, lb.	Heat in mill, Btu. per hr. Steam from 70% top gas		Comb. eff.	Average of rating, %
	Blast-furnace gas	Coal	Total					
1919	29,798	1225	31,023	2867	1567	998	63.7	156
1920	29,174	1150	30,324	2917	1652	977	59.1	145
1921	24,890	1660	26,550	2784	1330	834	62.7	123
1922	28,126	2160	30,286	2732	1495	942	63.0	131
Average 1919-22	27,997	1549	29,546	2825	1510	983	62.1	139
1923	30,592	2300	33,892	2640	1655	1022	61.8	131
1924	33,746	4270	38,016	2608	1687	1130	67.0	145
1925	34,104	5050	39,154	2690	1708	1142	67.0	145
1926	31,965	5850	37,815	2473	1565	1070	68.4	140
1927	36,323	4030	40,353	2575	1827	1215	66.5	148
Average 1924-27	34,034	4800	38,834	2589	1697	1139	67.2	144

The ratio of the heat in the steam produced from blast-furnace gas to the heat in the top gas supplied to the boilers is a measure of the total combustion efficiency of the plant.

*Reduction of Fuel Wastes in the Steel Industry, F. G. Cutler, Trans. A.S.M.E., vol. 44 (1922), p. 167.

(Continued on page 935)

Steel Plant Waste Heat Boilers*

This Paper Contains Much of Interest to Those Who Are Investigating Economies to be Effected by Recovery of Heat from Waste Furnace Gases—Engineering Features Set Forth

By R. H. STEVENS†

A RETROSPECT of the development of any stabilized industry will reveal the fact that the first consideration was the creation of an acceptable and marketable product, after which followed in order such stages of development as increase in quantity; improvement in quality; diversification of products and qualities; recognition of scientific principles of manufacture and processess; and finally, complete scientific control of all phases of the industry.

During this development, up to the last period, little attention was given to departments indirectly connected with the product, but with the advent of the last period, the indirectly as well as the directly connected phases of production, no matter how distantly related, succumb to the dictation of scientific management and engineering, to meet the well established laws of conservation, and in accordance with the exactions of competition.

Outside of a few instances, the steel industry paid little attention to conservation of waste heat until about 15 years ago, when it made a determined start to recover the enormous losses in coke-making, and to conserve heat wasted at almost all kinds of furnaces, by installation of waste heat boilers, recuperators, etc. Of course, the waste heat boiler had been in use for many years on puddling furnaces as the principal supply of steam for rolling and hammering the puddled iron.

It is probable that current efforts to recover this energy from fuel-fired heating and metallurgical processes common to the industry, differ in principle very slightly from those of 50 years ago. However, keen trade competition and increased cost of fuels and labor have added an incentive which was either lacking or successfully resisted until comparatively recently.

A history of progress in the results from waste heat boilers is probably of interest mostly to the boiler designer, the purchaser not being interested so much in past experience as he is in ascertaining what plant improvements are possible and what co-operation with the designer is necessary, in order to accomplish in the cheapest manner, both lower installation cost and subsequent lower operating and maintenance costs.

The distinguishing features of a waste heat boiler, its dependence upon convection rather than radiation, and other technical phases of the unit and its setting have been so thoroughly discussed in previous papers, that I will not attempt to review this matter even briefly, such information being readily available from the libraries.

I would like, however, to approach the subject in a slightly different manner by pointing out some of the modifications in conditions that now exist and

which must be considered in connection with such an installation.

The justification of such a unit may ultimately prove to have been mistaken. The selection of the unit itself at this stage of the art, is largely decided by the purchase price and form; but the co-ordination of many conflicting or provoking conditions due to its installation, may involve surprising expenditures. Because recent considerations show that not the performance of the boiler itself as a steam producer, but its effect upon the furnace to which it is attached, is the ultimate justification for its installation.

Possibilities and Limitations

Previous to adapting the waste heat boiler to existing furnaces observations will, of course, be made in order to determine the temperature at which the burned gases will enter the boiler. This, therefore, becomes a known quantity. Also the predetermined steam pressure to be generated by the boiler plus a justifiable differential (approximately 100 deg. F.) determines the temperature at which the same gases must leave the boiler, and so this also becomes a known quantity.

Both of these temperatures being determined, there is only one question of heat recovery existing, and that is the efficiency to be approached, regardless of the design or designer, the capacity of the unit still being dependent upon the quantity of gases flowing.

Air leakage and radiation losses in boiler proper are to be considered in this computation as unduly favoring the calculated efficiency, because each tends to increase the temperature drop between the two observed points in the gas flow. The matter of air leakage becomes almost negligible when the boiler is of the fire-tube type, and practically the only loss from the calculated efficiency is that caused by radiation. The determination of this efficiency being directly associated with the temperature drop through the boiler, it is possible for us to approximate very closely what results we may expect.

Bearing this in mind, and using gas analysis obtained from a representative producer-gas-fired basic open-hearth furnace, together with heat values taken

TABLE I—Composition and Btu. Per Cubic Foot (Standard) Burned Gases.

Composition (vols.)	Btu. at 450°F.		Btu. at 500°F.		Btu. at 600°F.	
	Per cu.ft.	Total	Per cu.ft.	Total	Per cu.ft.	Total
1	2	3	4	5	6	7
Per cent						
CO ₂ =	11.13	9.5	1.0574	11.0	1.2243	13.8
O ₂ and N ₂ =	88.87	7.0	6.2209	8.0	7.1096	9.8
Totals =	100.00	...	7.2783	...	8.3339	...
		say	7.28	say	8.34	say
						10.25

*Paper delivered before the American Iron and Steel Institute, New York, May 25.

†Chief engineer, Cambria Plant, Bethlehem Steel Company, Johnstown, Pa.

from the thermal capacity curves published by the American Gas Association, Tables I, II and III have been calculated and from them Figs. 1 and 2 plotted.

Table I shows that burned producer gases, when reduced to 450, 500 and 600 deg. F., contain sensible heat per cu. ft. (standard of 7.28, 8.34 and 10.25 Btu. respectively, provided of course the volumetric analyses of the gases is as per column 1 of same table.

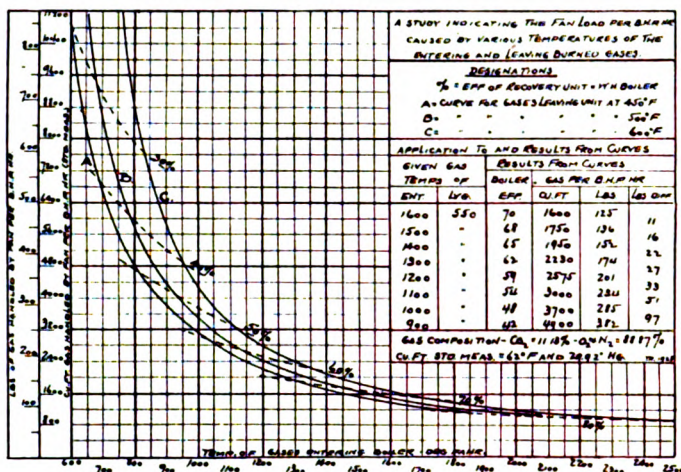


FIG. 1—Curves showing fan load at various temperatures of burned gases.

Table II shows the amount of burned gases handled per boiler horsepower hour with various temperatures of gases entering and leaving the boiler, also the corresponding boiler efficiency.

TABLE II—Calculations Based Upon One Cubic Foot Burned Gases.

Eff. of boiler 1	Btu. in exit gases per cu. ft. 2*	Per cent heat lost by boiler 3	Btu. entering boiler = col. 2 ÷ col. 3 4	Btu. to steam = col. 4 — col. 2 5	Temp. Fahr. corres. to col. 4 6	Cu. ft. gases passing per bhp.hr. 7†
Gases Leaving Boiler at 450 deg. F.						
80	7.28	20	36.40	29.12	1850	1149
70	7.28	30	24.27	16.99	1300	1970
60	7.28	40	18.20	10.92	1020	3065
50	7.28	50	14.56	7.28	820	4600
40	7.28	60	12.13	4.85	680	6900
30	7.28	70	10.40	3.12	600	10729
Gases Leaving Boiler at 500 deg. F.						
80	8.34	20	41.70	33.36	2080	1004
70	8.34	30	27.80	19.46	1450	1720
60	8.34	40	20.85	12.51	1140	2675
50	8.34	50	16.68	8.34	930	4014
40	8.34	60	13.90	5.56	780	6021
30	8.34	70	11.92	3.58	670	9350
Gases Leaving Boiler at 600 deg. F.						
80	10.25	20	51.25	41.00	2520	816
70	10.25	30	34.17	23.92	1760	1400
60	10.25	40	25.63	15.38	1360	2177
50	10.25	50	20.50	10.25	1160	3266
40	10.25	60	17.10	6.85	950	4887
30	10.25	70	14.64	4.39	830	7625

*Col. 2 = cols. 3, 5, and 7 of Table 1.

†Col. 7 = 33475 ÷ col. 5. 33475 being the Btu. required for one bhp.hr.

Fig. 1 is simply a graph made from columns 1, 6 and 7 of Table II.

A study of these tables with Fig. 1 will serve to show the rapid increase in pounds of gases to be handled, or increase in fan load, when the temperature of the gases entering the boiler is reduced to 1000 or 900 deg. F.

Table III and Fig. 2 are simply extensions of the previous tables and figure, and serve to show the efficiency of heat transfer (boiler efficiency) fixed by certain temperatures of entering and leaving gases, also total heat recovery from the furnace when the gases leave the furnace at 3000 deg. F.

It will be observed from Fig. 2 that to permit the gases leaving the boiler at 500 deg. F. (= 388 deg. F. or the temperature of dry steam at 200 lb. gauge plus 112 deg. F. differential) if they have entered the boiler at 1600 deg. F., requires 73 per cent efficiency of the recovery unit or a complete reclamation of heat from the gases, as they left the furnace at 3000 deg. F. or 38 per cent.

Again, had burned gases entered the boiler at 900 deg. F. and no other condition changed, we would have about 48 per cent efficiency of the recovery unit, corresponding to a complete reclamation of 13 per cent.

Changes of gas composition or temperature of gases entering or leaving the boiler will change the boiler efficiency as herein indicated, and changes of temperature of gases as they leave the furnace will change the percentage of total recovery. However, I submit these figures and calculations as being representative, believing that no misleading conclusions will result.

The submitted calculations further extended will indicate that between 13 and 14 per cent of the heat

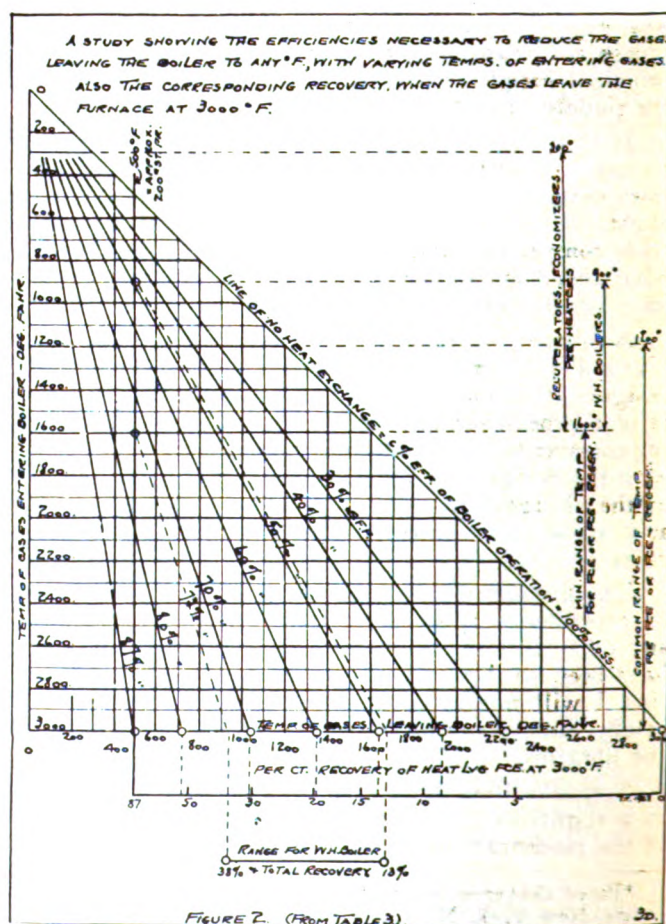


FIG. 2—Correlation of gas temperatures and efficiencies.

TABLE III—Calculations for FIG. 2.

Boiler efficiency 1	For plotting diagonal lines						For per cent recovery		
	Tempera- ture entering deg. F. 2	Gases leaving		Tempera- ture entering deg. F. 5	Gases leaving		Temp. of gas leaving fu'ce. = 3000° Temp. of gas leaving boiler = 500° Temp. of gas entering boiler = col. 9		
		Btu. per cu. ft. 3	Temperature deg. F. 4		Btu. per cu. ft. 6	Temperature deg. F. 7	Btu. to steam = tab. 2 col. 5 8	Temperature of col. 8 = tab. 2 col. 6 9	Per cent recovery = col. 8 ÷ 63.45* 10
80	1600	6.2	400	3000	12.7	720	33.36	2080	52.6
70	1600	9.3	560	3000	19.0	1040	19.46	1450	30.6
60	1600	12.4	700	3000	25.4	1350	12.51	1140	19.7
50	1600	15.5	870	3000	31.8	1640	8.34	930	13.2
40	1600	18.6	1020	3000	38.1	1930	5.56	780	8.8
30	1600	21.7	1170	3000	44.4	2220	3.58	670	5.6

*63.45 = Btu. per cu. ft. at 3000 deg. F.

goes to the stack, which together with a 38 per cent total recovery of the heat in the gases as they come from the furnace, indicates that approximately 50 per cent of the total heat was supplied for the furnace and its radiation losses.

As the principal work of an open-hearth or heating furnace is producing or preparing steel, we believe that the furnace itself should be so constructed that at least 50 per cent of the heat leaving in the gases should be returned for the use of the furnace itself. Therefore, when the gases leave the furnace, sufficient heat should be recovered from them and be returned to the furnace, so that their temperature at entrance to a waste heat boiler should not be over 1600 deg. F. Above this temperature, the required efficiency of recovery is impractically high, and also indicates that regenerator capacity is too small. Likewise, should the gases to the boiler fall to less than 900 deg. F. the efficiency of the recovery units is low and the total recovery (13 per cent) not sufficient to warrant the installation or operation of a waste heat boiler.

Recovery by means of a boiler may not necessarily mean improvement in heating practice nor a reduction of the total amount expended per month for fuels, whereas a reduction in the temperature of the gases leaving the furnace positively means a reduction in fuel consumption, either features remaining constant.

The use of the waste heat boiler has no doubt been an attempt to make amends for inefficiencies attending the majority of furnaces, particularly those designed and installed in the past.

Better furnace designs, incorporating within them the necessary features for more complete fuel utilization, seems to be the trend of modern engineering, and each installation thus completed must necessarily reduce the field of application of the waste heat boiler.

Location

Relative to open-hearth furnace. In order to reduce to a minimum the radiation losses between the checkers and the boiler; it is of course advisable to locate the latter as close to the former as is possible. However, and generally, in connection with furnaces already installed, this unit has not been planned, and later in order to provide for it, longer, more costly and less advantageous operating connections have to be made, any one of which detracts from the advantage to be gained, either by increased overhead charges due to increased installation costs, or by increased

operating cost due to inaccessibility, or by both, and by heavier draft losses.

Relative to the general demand for steam. As probably not over 15 to 30 per cent of the total amount of steam generated by the waste heat boilers is required by the furnaces and their accessories, and as the widely distributed use of steam is generally being eliminated by electrification, it is apparent that it will be necessary to carry the greater part of this steam to some distant point, thus requiring a long steam line, losing a certain portion of the reclaimed energy because of drops in pressure and temperature (condensation), and adding to installation cost for steam line and covering. The loss due to long lines existing in some older plants is surprising. In some cases it is, for steam lines alone, about 10 to 15 per cent of all steam generated.

Relative to electric power plants. Due to the ever increasing demands for electric-driven power units throughout iron and steel plants, the consumption of steam is becoming more and more localized at the electric generating stations, and in order to effect maximum savings, it is necessary to locate the boilers and generators as close together as possible, or under the Same roof, which of course is impossible when waste heat boilers are considered.

Relative to steam pressures. Since the modern trend of boiler operation and steam demand is toward higher pressures, the gases leaving the boiler must also be increased in temperature, thus reducing the range of temperature drop through the boiler. This in turn demands higher boiler efficiency, with corresponding higher gas velocities and increased draft-losses through the boiler, with a resultant increase in power required to operate the fan, which latter is still further augmented by increased air leakage through the boiler settings due to increased draft. Air leakage is, of course, minimized when the fire-tube single-pass boiler is installed.

To compensate for the higher gas temperatures leaving the boiler, separated economizers or their equivalents in heating surface must be provided; or air preheaters (recuperators) operating in conjunction with the furnace regenerators may have to be installed.

Great care must be exercised in the analysis of these matters in order to avoid dissipating all advantages gained from reclamation.

Provisions For and Prevention of Explosions

In general, such furnaces as use their gas and air checkers for their designed purposes very likely pro-

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duce an explosion at each reversing of the valves. When no damaging result occurs, it is probably not because the explosion does not take place, but rather because there is sufficient venting to the stack for the momentary increase in pressure. This is quite often noticeable in the discharge of gases from the top of the stack at reversing time. First there appears a short, rather decided puff of darkened fume or smoke, followed by a brief period of no emission, then a long period of fairly dark smoke flowing rather lazily, finally diminishing to the customary flow.

The first of these, or quick puff, was probably the true explosion caused by the meeting and igniting of the air and gas, which filled the flues between the reversing valves and the checker chambers.

The final period of slow flow of darkened gas was probably the result of the checker chambers discharging their contents, which burned in the flues.

The intermediate period of no apparent flow was probably the result of the first explosion, acting both toward the checker chamber and toward the top of the stack, the former showing no effect at the hearth because of the restriction offered by the checker work, the latter being very apparent because of no restrictions except the bends in the flues.

Observations at night seem to indicate that the period between the appearance and disappearance of the luminosity of the gases at the top of the stack and the discharged gases are back to their normal flow, and color, is 20 to 45 seconds.

Therefore, any furnace employing regenerators for preheating both gas and air, and operated with a connected system of reversing valve mechanism, wherein all valves are thrown at the same time, almost invariably produces an explosion when reversing, and this is particularly serious when a waste heat boiler is inserted between the regenerators and the stack. There have been a number of methods suggested to guard against such explosions or to minimize their effect, such as a gas jet burning at the junction of the gas and air flues leading to stack; mechanically or hand delayed opening of gas or air chamber to stack; opening stack damper before reversing; or suitable explosion doors, properly located.

A gas jet requires constant supervision. Opening stack damper usually requires a separate operating

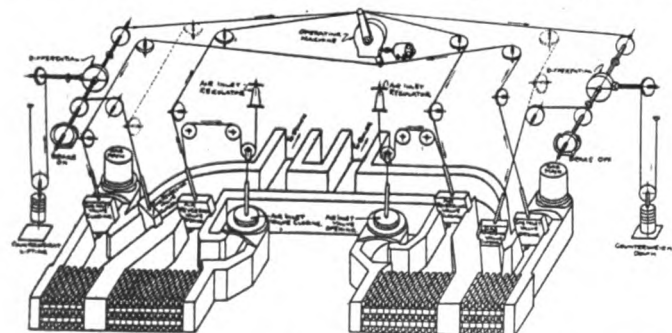


FIG. 3—Diagram showing valves in middle of reversing stroke; direction of movement of all valves shown by arrows; gas reversing valve on left hand side is stationary while rig is lifting the counterweight; gas reversing valve on right hand side is lowering with the other valves; after a set lapse of time, the brake on left side is released and counterweight falls raising gas reversing valve; on next reversal the delayed action takes place in similar manner on right hand side; dotted lines indicate arrangement gas reversing valve ropes previous to installation of waste heat boilers.

mechanism and produces serious wear on a very large damper. Explosion doors are always a menace to safety.

Such provisions as explosion doors opening to the air and located between the valves and the boiler or at the boiler settings are only partially successful. They should preferably be placed at some point where the gases are compelled to make a change in direction, but so arranged that the force of the explosion will not have to go around a corner to seek relief.

The ideal method of operating is, of course, one in which the gas and air checker chambers and flues are unloaded of their contents at different times.

To incorporate this feature in a train of reversing mechanism is possible and will be successful in proportion to the time provided for the unloading of one of these chambers, which, of course, must be determined from experiment with the various stack drafts employed. Fig. 3 shows such a method in diagrammatic form.

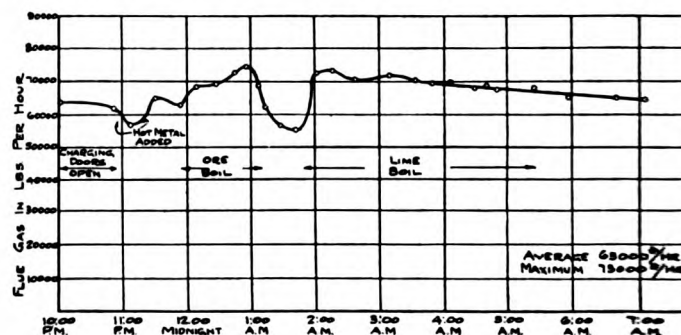


FIG. 4—Curve showing weight of flue gases entering boiler during heat of an 80-ton producer gas fired open-hearth furnace.

To operate such a method by hand may be equally successful, if the judgment of the operator is good.

Another preventive measure and one that aids the efficiency of the installation is the closing of any air leaks, especially around the stack dampers. Failure to do this may render ineffective the precautionary measures of the preceding paragraphs.

Physical Condition of Tubes

An analysis of the average dust carried over from an open-hearth furnace with the waste gases is about as follows:

As Reported by Chemist.		As Probably Existing.	
	%		%
Fe	38.89	Fe ₂ O ₃	55.56
SiO ₂	0.98	SiO ₂	0.98
NaCl	2.58	NaCl	2.58
Soluble in H ₂ O	23.39	Soluble in H ₂ O ...	23.39
		Ignition loss	17.49
		Total	100.00

In the case of horizontal tubes rather effective dust-blowing means must be employed due to the fact that this dust may contain as much as 40 per cent Fe. Owing to this weight, the effective range of steam jet is rather limited. This condition is probably not very much different from that accompanying blast furnace gas firing.

Induced Draft Fan and Methods of Driving

Owing to the restricted space for installations, it would seem that the high-speed fan should receive

first consideration, due to its lesser size and cost. However, consideration of the nature of the service, that is, temperature of the gases together with the probable temperature and dusty conditions of the surrounding air, generally leads to preference for the large, slow-speed unit.

Choice of double or single inlet depends considerably upon the location, the double inlet requiring more floor space and generally costing more, while the single inlet may not be as efficient a unit, and due to the overhung wheel, may result in more mechanical troubles.

Water-cooled bearings are strongly advised, but cooling the shaft by means of cold air drawn in through an annular sleeve around it should not be necessary if the boiler has extracted the proper amount of heat from the gases.

Whether the fan should be driven by an electric motor or a steam turbine seems to be a much debated question. One of the features entering into the matter is whether or not it is necessary to embody the varying speed features. The first reaction in considering either means for driving a fan is in favor of the steam turbine, but when it is further considered that the turbine almost necessarily means a non-condensing unit, exhausting more steam than can be used for heating boiler water, carries with it a speed reducing gear and requires much more attention than the electric motor, the decision generally favors the latter. I know at least two cases where the turbines were changed over to electric motors even with purchased power, but I do not know any case where motors have been replaced with steam turbines.

Draft being one of the most important features attending the furnace operation, any change affecting it must necessarily be viewed with considerable concern. In this event, both engineers and operating superintendents are likely to feel that ample provision must be made for any and all variations, with the result that such provisions may afterwards be found to have been carried beyond the necessary limits.

Variable-speed motors for the purpose add considerable expense to the installation, and eventually serve only to determine the proper constant speed which should be used.

Generally the installation of waste heat boilers will require installing additional feed-water heating capacity, or should there be such capacity available at some existing heater, the chances are it will be located some distance away and without available exhaust steam for the added load. In this case, it may be possible to heat the feed-water by first passing it through the water-cooling equipment of the furnace to which the boiler is attached.

In all cases the fans to be installed should be of sufficient capacity to easily handle the amount of gases formed when operating the furnace at its maximum rate, and any calculation for this amount based upon stack gas analysis and the fuel consumed must include the consideration that only 80 per cent of the total amount of gases generated are thus represented, the other 20 per cent coming from chemical reactions of the charge. Fig. 4 shows a typical flow of gas from an 80-ton open-hearth furnace.

(To be continued)

Production of Bituminous Coal

Soft coal production for the past few weeks has varied but little. The Bureau of Mines reported the output for the week ended June 9 as 8,412,000 net tons and for the week ended June 16 as 8,335,000 net tons. Preliminary railroad shipping reports show that the total quantity mined during the week ended June 23 was about 8,360,000 net tons.

Omission

Omission was made in the June issue to mention the Freyn Engineering Company as the engineers and designers of the power plant of the Central Alloy Steel Company which plant was described under the title, "Steel Plant Boiler Firing Flexible." The Freyn Engineering Company is the patentee of the heat exchanger mentioned in the article.

Firing of Gas and Pulverized Coal

(Continued from page 930)

Table II shows this comparison for the Ensley blast-furnace plant for nine yearly periods, the four from 1919 to 1922 showing conditions existing prior to the installation of these boilers, and from 1924 to 1927 conditions after the boilers were in service and conditions adjusted, based on the assumption that 70 per cent of the total heat in the top gas was delivered to the boilers. As the furnace gas is not washed at Ensley, the calculated heat in the top gas included the sensible heat.

As the stoves and all losses were charged with 30 per cent of the top gas for each period, this comparison shows that the combustion efficiency of the boiler plants on blast-furnace gas has been materially improved. On the basis of the efficiency obtained prior to this installation, 31,450 bhp. would have been generated from the gas available in the latter period. As 34,032 bhp. was generated, there was an average gain due to increased efficiency of gas burning of 2,582 bhp.

Part of this gain can be attributed to the replacement of about 3,000 rated bhp. in two-pass boilers by more efficient three-pass boilers, but as there are still about 14,000 rated bhp. of two-pass Rust and Wickes boilers in service, most of the gain in efficiency can be attributed to the system of gas distribution which allows the powdered-coal-fired boilers to utilize the surplus blast-furnace gas and maintain a relatively steady supply to stoves and boilers which are fired only by blast-furnace gas.

By this installation and the installation of a motor on the rail-mill rolls, it has been possible to shut down the boilers at the blooming mill and very materially improve steam condition, both as to pressure and cost of operation.

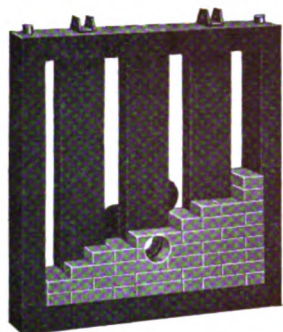
The comparative operating costs at the blast-furnace boiler plants for fuel, as well as for producing labor and for repairs and maintenance, are materially lower than before and we consider that this installation has been very successful.

In conclusion, the author would say that at a new blast-furnace plant now being built by the Tennessee Company at Fairfield, the same general method of regulation of gas fuel and the storage system of powdered-coal firing, with separate coal-pulverizing plant, is being installed.

WITH THE EQUIPMENT MANUFACTURERS

Open-Hearth Door and Frame

A new type of water-cooled door patented by the Williams Welding & Mfg. Company, of Charleroi, Pa., has a water covered panel construction tying in the brick in such a manner that doors have needed no re-lining during the entire run of a furnace. The doors



are constructed of plate and heavy angle securely welded throughout. These angles give a rigid construction that does not warp and renders the door less liable to be damaged by the charging box and scrap load. A forced circulation of water is carried in a manner similar to the frame. The arch and legs of the frame is formed of extra heavy steel tubing. In the frame the water flows in at the top of the arch and passes down the legs into the inner leg and then up and across the body of the frame at which point it is discharged. The legs do not bow nor does any part of the frame warp. It has stood the test at one of the large steel plants for the past three years.

Palmer-Bee Herringbone Speed Reducer

The Palmer-Bee Company has just recently developed a line of herringbone speed reducers which embody a number of unusual advantages. The gears are of the Sykes continuous-tooth herringbone type, which are claimed to be efficient, durable and quiet-running.

Small size gears are cut from steel forgings and the larger sizes from annealed electric steel castings. All pinions are cut from alloy steel forgings. Bearings are fitted with replaceable phosphor bronze bushings. All shafts are cut from high grade alloy steel, accurately turned and ground to size.

The housing is constructed of cast iron, strongly ribbed at points where the stress is greatest, and split on the center line of the shafts so that the upper half, or cover, can be removed. Bearing caps are replaceable so that the removal of the cover does not disturb the bearings. Lubrication is by means of a patented oil bath, splash and gravity feed system, which eliminates the necessity of external grease cups of any kind.

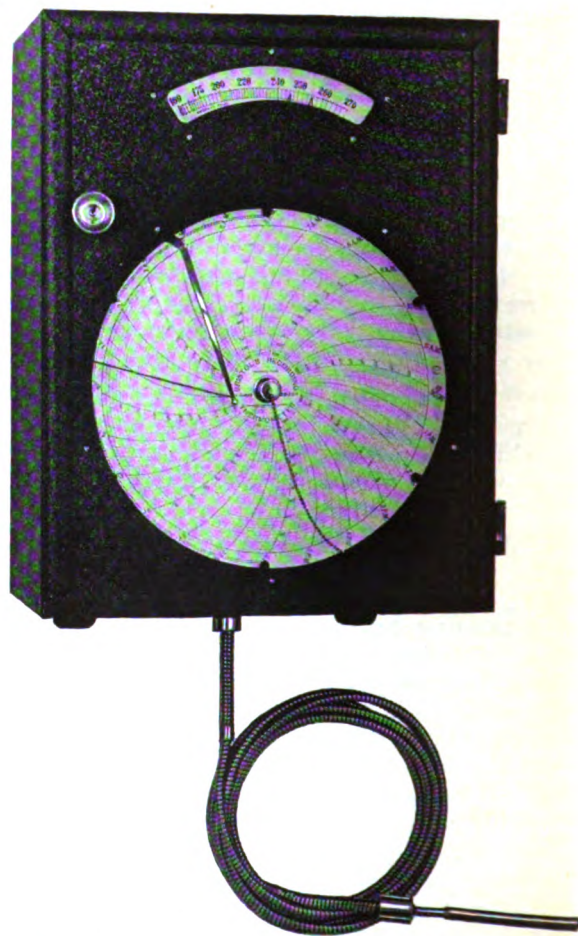
Simplicity of design, accessibility of mechanism, compactness and long life are the outstanding claims advanced for it by the manufacturers.

New Recorder Controller Model 267

A new recorder and contacting controller is now being offered by The Bristol Company. This combines in one case the features of a rugged recorder and a thermometer controller which offers a more compact outfit than separate instruments.

The equipment is a single pen recording system with controller system and scale mounted directly above it. The recording pen and moving contact of the controller are each actuated by separate pressure element which are exactly alike in construction. These elements are connected through one capillary tube to the sensitive bulb, and arranged in this way the record is not impaired in the slightest degree by retarding effect of the controller. Also the recorder draws a true record both above and below the control point.

The controller is set to the desired temperature by moving an index pointer over a scale to the exact degree to be controlled. This index pointer is very long and it is thus possible to adjust it accurately and easily.



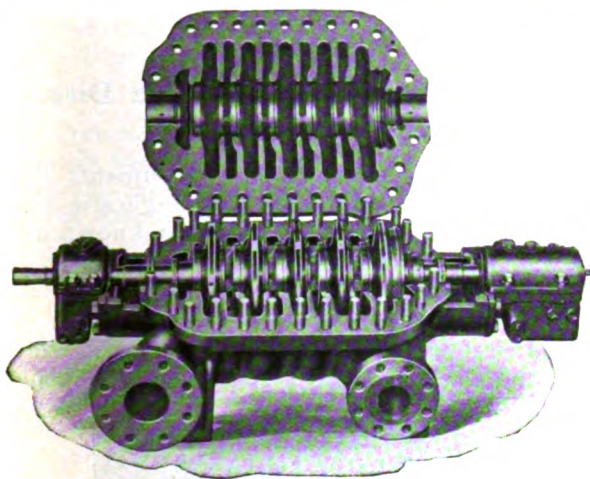
Zero adjusters are provided for both recorder and controller pressure elements. They are not easily tampered with by unauthorized persons because they can be moved only after being unlocked with a screw driver.

The large current carrying capacity of this controller makes it possible to adapt the instrument to many control applications without the use of relays. Bristol's Motor Operated and Solenoid Controller Valves may be connected directly to the terminal. Also for electric heating control, main line switches may be operated without the addition of relays.

New Multistage Centrifugal Pump

A new multistage pump has recently been developed by the Moore Steam Turbine Corporation of Wellsville, N. Y., for high pressures which has a higher efficiency than the ordinary centrifugal pump. The design of the impellers is such that the velocity of the water entering the eye of the impeller is low thus preventing a large portion of the losses at this point. The method of fitting the shaft sleeves on the pump is such that it eliminates all possibility of buckling and therefore leakage along the shaft. The impellers are relatively small in diameter with large openings at the outlet thus assuring that they can be properly cleaned and finished to a smooth surface. The pumps are of the single suction type and are equipped with an adjustable balancing device so that the proper clearance can be maintained at all times thus preventing an excess leakage through the balancing device.

The casing of the pump is small in diameter and is made with an elliptical section instead of a circular section. The advantage of the elliptical is that the horizontal



joint between stages will tend to tighten as the pressure increases. This design practically eliminates interstage leakage.

Moore single stage pumps are all of the double suction type hydraulically balanced. The guided inlet feature insures the entrance of water to the impeller with minimum shock loss. High efficiencies over an exceptionally wide range are therefore permanently maintained.

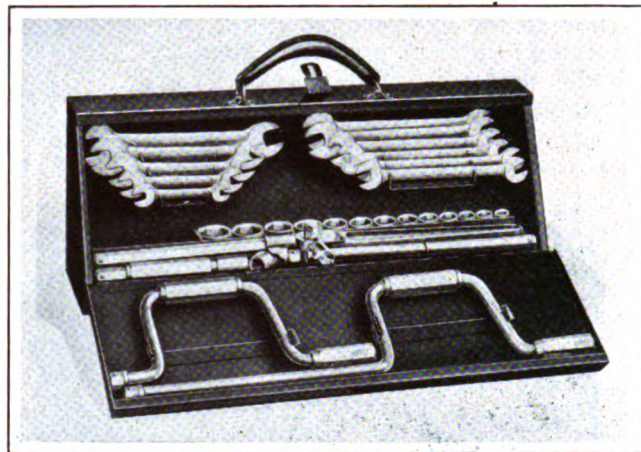
New Williams-Husky Combination Wrench Sets

J. H. Williams & Co., Buffalo, and the Husky Wrench Company, Milwaukee, have recently announced two wrench sets combining high grade chrome-alloy steel open end and socket wrenches in standard assortments.

No. 642, Williams-Husky Mechanics' Wrench Kit is a combination of Williams' "Superrenches" and

"Husky" socket wrenches for the garage mechanic. This assortment is not only a complete wrench set in itself; the practical and substantial tool kit provides ample room for extra tools—hammers, hacksaw, files, etc.

The kit includes 5 Williams' "Superrenches" (choice of engineers' or obstruction pattern), 10 different openings $\frac{3}{8}$ in. to $\frac{7}{8}$ in.; 6 tappet pattern



"Superrenches" with openings $\frac{1}{2}$ in. to $\frac{7}{8}$ in.; and 13 "Husky" chrome alloy steel sockets, sizes $\frac{7}{16}$ in. to 1 in. hexagon, with the 7 most popular wrench handles (either $\frac{9}{16}$ in. hexagon or $\frac{1}{2}$ in. square, as desired). The kit is made of 20 gauge auto body steel, finished in durable black lacquer. Size, $20\frac{1}{2}$ x $5\frac{1}{2}$ x 8 in. high.

No. 321, Williams-Husky Economy Wrench Set is a smaller assortment than the above kit but is sufficiently comprehensive to meet average everyday needs. The compact metal box measures $11\frac{1}{4}$ x $5\frac{5}{8}$ x $2\frac{1}{4}$ in. and is designed to fit the side pocket of any car.

This arrangement enables each company to merchandise in combination sets the other's quality open-end, or socket wrenches. It is made for sales purposes only, and is limited to the items which constitute these sets. Information will be furnished by either of the above manufacturers.

B. & W. Kaolinic Refractories

The Babcock & Wilcox Company has after extensive research perfected certain refractory products using a kaolinic material as a base. The special methods developed by this company to process the kaolinic material produces refractories having such properties as adapt them for use under severe service conditions. They are thus suited for those parts of the furnace structure that are subjected to high temperatures and other operating conditions which tend to shorten the life of furnace linings.

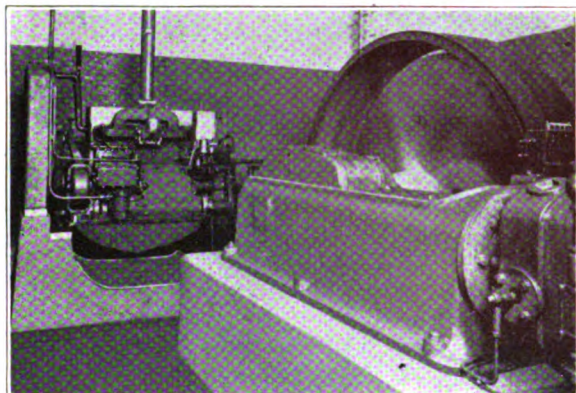
The B. & W. refractories are marketed under the names of: "No. 80 Firebrick" (standards and special shapes), "No. 80 High Temperature Cements," "No. 80 Tank Blocks," "No. 80 Sagger Base," and "No. 101 Moldable Mixture."

The features of the No. 80 refractories are high melting points, small shrinkage, low coefficient of expansion, stability under loads at high temperatures, and resistance to spalling and abrasion.

Air Compressor Driven by High-Speed Diesel Engine

An interesting application of Diesel power is shown by the accompanying illustration. It consists of a two-stage 16 x 10 x 14-in. air compressor of the horizontal type driven by a four-cylinder Buda-M.A.N. Diesel engine of 6 in. bore and 8 in. stroke operating at 950 rpm. A twin disc clutch is enclosed in a housing bolted directly to the flywheel enclosure, and the engine is connected to the compressor by means of a short belt and idler pulley.

The compressor delivers 400 cu. ft. of air per minute against a pressure of 130 lbs. per sq. in., and the air is used to operate Harris air-lift pumps in a deep



well, raising the water from a depth of approximately 167 ft. and delivering it to a storage tank.

The engine is the full Diesel type, with a normal operating speed of 1000 rpm. and rated at 92 hp. at that speed. The actual brake-horsepower load varies from 80 to 87 hp.

Fuel with a gravity of 28 to 30 degrees Baume is used, and is supplied from the storage tanks through a Niagara meter to a tank mounted on the engine-room wall. From the latter the fuel is fed to the injection pump on the engine by gravity, and a Zenith duplex filter is installed in the line to remove any foreign matter that may be in the fuel. Fuel is injected by the mechanical or solid-injection system, which is under control of the built-in governor. The time of injection can be advanced or retarded manually, and the quantity of fuel regulated, so that the speed of the engine can be controlled manually as well as by the governor. The fuel is conducted from the injection pump through steel tubes to dividers mounted on the cylinder jacket, from which the fuel is delivered to spray nozzles on opposite sides of the combustion chamber of each cylinder. The two nozzles are diametrically opposite, and the fuel is sprayed into each chamber parallel to the top of the piston. The nozzles are so arranged that the "sprays" pass to each side of the radial center line of the combustion chamber, so that the fuel spray cones do not meet, thereby causing turbulence of the oil particles. Consequently, combustion is complete and efficient, as evidenced by the fact that fuel consumption ranges from 0.40 to 0.45 lbs. per brake horsepower, and that smoke is absent from the exhaust under widely varying loads and speeds.

Lubrication is accomplished by means of a positive gear-driven pump of large capacity, a pressure of 45 lbs. per sq. in. being maintained to all bearings, piston pins, and to the valve gear on each cylinder head. All

moving parts are enclosed to promote cleanliness and lubricating oil economy, and a filter cleans all oil before it passes back into the engine. A lubricating oil reservoir fitted with gauge glass, settling tank and screen is mounted on the flywheel housing. The dry sump system is used to insure uniform lubrication under all conditions.

A small air-cooled, two-cylinder, opposed-type, gasoline engine, shown at the right in the accompanying illustration, is mounted on the flywheel housing and is used for starting duty. This engine is connected by a conventional type Bendix gear through a manually operated clutch and a short roller-chain drive. The Diesel starts with the same kind of fuel used for regular operation, and no compressor or preheating devices are required.

The Buda-M.A.N. Diesel engine is built under license and patents of the M. A. N. Company of Augsburg, Germany, with whom Dr. Rudolph C. Diesel was associated until his death. It was in the M. A. N. shops that Dr. Diesel built his first engine about 35 years ago, and the outstanding success of M. A. N. Diesels is proof of the correctness of the basic design. The Buda-M.A.N. engine is of the same design adapted to American standards of measurement, and is manufactured by the Buda Company, Harvey, Ill., who have been building internal-combustion engines of the heavy-duty industrial type for nearly 20 years, and who are working in close co-operation with the M. A. N. Company and deriving the benefits of over 30 years of experience in Diesel engine manufacture.

New Westinghouse Portable Direct Current Instruments

A new line of portable d.c. instruments has recently been developed by the Westinghouse Electric & Mfg. Company. These instruments, known as type PX2, are compact, accurate, and are particularly suitable for automobile, battery, radio, and miscellaneous testing.

They are of the permanent magnet moving-coil type and operate on the D'Arsonval principle. The



moving coil rests on hardened steel pivots moving in sapphire jewel bearings. The mechanism is mounted on a molded micarta base and has a case of the same material. A mirrored dial and a knife edge pointer facilitate accurate reading.

This line of instruments includes millivoltmeters, double-range voltmeters, milliammeters, ammeters, radio frequency ammeters, and galvanometers.

TRADE PUBLICATIONS

The Palmer-Bee Company has recently issued a new 48-page catalog explaining the superiorities of PB-Sykes continuous-tooth herringbone gears. This book also describes their line of herringbone and improved mill type spur gear speed reducers. It contains tables of horsepower ratings and dimensions of standard size units, a list of the advantages over open drives, instructions regarding their lubrication, installation, etc. Copies will be mailed gratis to anyone in charge of power maintenance or the purchasing of this equipment.

* * *

The user of refractories will find much interesting information in a folder of bulletins issued by the Crescent Refractories Company, under the title "Charts, Formulae and Simple Rules." Bulletins No. 1 to No. 20, which are listed as Series 1, have a special appeal to those desiring information of a practical nature.

* * *

"Fire Brick" is the title of a catalogue which describes the products of the A. P. Green Fire Brick Company, of Mexico, Mo. This company manufactures high-alumina fire brick in all shapes and for all purposes. The catalogue besides giving information concerning the company products contains considerable data of practical value.

* * *

The Oxweld Acetylene Company is distributing a pamphlet in which is set forth, by illustration and test, the uses and construction of the Carbic Light. This light finds extensive service for illuminating outside construction and repair work.

* * *

A 24-page booklet giving a description of an improved method of generating herringbone gears, has been issued by W. A. Jones Foundry & Machine Company. It shows tooth forms, dimensions, price lists in cast iron and steel for recommended face widths, and horsepower tables for open gearing.

* * *

A booklet just published by The Gunit Corporation, Rockford, Ill., tells an interesting and understandable story of Gunit, a "new graphitic steel." It reviews over 12 years of research in the development of this new metal which is a high-carbon steel with graphitic carbon uniformly distributed by a precipitation process throughout the castings giving qualities of strength, toughness, rigidity, and wearability under friction. By means of microphotographs, the difference between Gunit and other graphitic metals commonly used is clearly shown. The application of Gunit as shown include the use of Gunit for brake drums, clutch plates, cams, pressing dies, large and small gears, surface plates, jigs, fixtures, bushings, heavy duty bearings, punch frames, bases, steam engine cylinders, pistons, rings, valves, gauges and rollers. Some of these applications, described in detail in the booklet offered, will undoubtedly suggest new uses. The Gunit Corporation will forward a copy of "The Story of Gunit," postpaid to any one interested.

"Circle C Steel for Cutting the Harder Metals" is discussed in a folder being distributed by the Firth-Sterling Steel Company, McKeesport, Pa. The text gives examples of the performance of tools made from Circle C steel and gives directions for the heat treatment in forging, annealing and hardening the tools and suggestions regarding grinding. A list of the other Firth-Sterling steels is appended.

* * *

"Microscopes in Metallurgy" is the title of a 16-page booklet issued by the Bausch & Lomb Optical Company, Rochester, N. Y. It describes new and standard equipment for special purposes and for general use, and includes lists of prices.

* * *

Due to the semi-arid climate of Spokane, demands upon the city water works reach a maximum of over 550 gals. per capita per day in July. There is, however, an apparently unlimited source available in artesian wells, which, with cheap power from hydro-electric plants and large, efficient, modern pumps, makes it possible to supply water having a temperature of about 48 deg. F. and absolutely free from bacterial life, at a comparatively low cost per 1,000 gals. The new Spokane Up-river Pumping Station is described in a leaflet now being distributed by the De Laval Steam Turbine Company of Trenton, N. J., which supplied the pumping equipment.

* * *

A folder from Garden City Fan Company, Chicago, describes the Garden City cycloidal turbine compressors for all purposes requiring pressures up to 3 lbs. and equivalent in vacuum. The folder gives performance curves at constant and varying speeds and includes a price list.

* * *

"Manufacture and Use of Slag Products" is the heading to Symposium No. 4 issued by the National Slag Association, 937 Leader Building, Cleveland, Ohio. As the name implies it lists the uses of siag for various purposes.

* * *

"The Safety Valve", a publication in leaflet form, of the Heine & Ladd Water Tube Boiler companies, gives information on matters pertaining to boilers. For copies address either company at 200 Madison Avenue, New York City.

* * *

Elwell Parker Tractors are described in detail in catalogue No. 150. The catalogue is well illustrated and gives, besides general information, specifications for the various types.

* * *

The Combustion Engineering Corporation has placed in the mails a 27-page catalogue, U-3, in which, by illustration and text, the design and application of the Lopulco Unit System for burning pulverized fuel is attractively set forth. Copies will be furnished on request from 200 Madison Avenue.

* * *

Bristol's Counters and their various applications form the text in a leaflet distributed by The Bristol Company, Waterbury, Conn. This counter is applicable for all purposes where revolutions or strokes are to be counted. Several special features are embodied in this counter.

TRADE NOTES

Botfield Refractories Company, Swanson and Clymer Streets, Philadelphia, Pa., announce that, effective June 1, the distribution of their well-known products, Adamant Fire Brick Cement, Adachrome and Adachrome Fines and The Adamant Gun for Toledo, Ohio and vicinity will be handled by The Builders & Industrial Supply Company, 4090 Detroit Street, Toledo, Ohio.

* * *

The Northern Engineering Works of Detroit, makers of cranes and hoists, recently appointed The Interstate Supply Company, Commercial Trust Building, Philadelphia, as direct factory representative for the Philadelphia district; Mr. W. H. Beyer of the latter company personally assuming charge of the account. Mr. Beyer is exceptionally qualified for this position from both technical and local standpoint, having been connected for about 12 years with the Philadelphia office of Manning, Maxwell & Moore.

* * *

The Veeder Manufacturing Company of Hartford, Conn., and The Root Company of Bristol, Conn., merge as Veeder-Root Inc. The Veeder Manufacturing Company of Hartford, Conn., for many years manufacturers of small, high grade counting machines and fine die castings, and The Root Company of Bristol, Conn., well known manufacturers of heavy duty counters, hinges and stampings, have united in a merger to be known as Veeder-Root Inc.,

* * *

Two new factory buildings, all the structural work of which will be arc welded instead of riveted, are now being erected by the General Electric Company. One of these will be an addition to the General Electric plant in Bridgeport, Conn., and the other will be located at the company's Pittsfield, Mass., plant. These mark a second step in the General Electric program, recently announced, of utilizing welding in the construction of its new buildings.

* * *

The General Electric Company announces price reductions on popular types of Mazda flashlight, radio panel, toy train, mine and hand lantern lamps. These reductions, which have been made possible through improvements in manufacturing processes, will mean a saving to the consumer of about 20 per cent in his future purchases.

Since 1914, prices on miniature Mazda lamps, including lamps for automobiles, have been reduced approximately 50 per cent. During the same period motor vehicles have been reduced in price about 12 per cent while all commodities have increased 62 per cent in price.

* * *

The Celite Company of Los Angeles, have purchased the plant and property of the National Magnesia Manufacturing Company at Redwood City, about 25 miles south of San Francisco. The business of the latter company will be continued under the name of the National Magnesia Company. Both The Celite Company and the National Magnesia Manufacturing Company started in business in 1912.

The manufacturing plant of The Celite Company is located at White Hills, (near Lompoc) California. This is the largest plant in the world engaged in the manufacture of diatomaceous earth products (including heat insulating materials, filter-aids, admixtures for concrete and many grades of mineral fillers). The business at Redwood City includes the manufacture of magnesia, asbestos and diatomaceous earth insulating materials. This business will be continued and the scope of its service enlarged under the new name, National Magnesia Company.

* * *

On March 28th, The Linde Air Products Company opened a new district sales office at 48 West McLemore Avenue in Memphis, Tenn. Other Linde district offices are maintained in 25 leading industrial centers. Users of Linde Oxygen, Oxwell welding and cutting equipment and supplies, Prest-O-Lite acetylene and Union Carbide in the district which consists of Western Tennessee, Northern Mississippi and Eastern Arkansas will find this office adequately prepared to handle their needs. Mr. H. N. Smith will be district manager in charge.

* * *

The Hydraulic Pressed Steel Company, Cleveland, Ohio, has been purchased by the Truscon Steel Company, Youngstown, Ohio, and will be operated as their Pressed Steel Division. The entire plant is being completely modernized to insure the most efficient production. With this increase in facilities, the Truscon Steel Company will have one of the largest capacities for furnishing pressed and deep drawn steel of every description. The improvements are proceeding rapidly, and full productive capacity will be available shortly. Inquiries may be addressed either to the Truscon Steel Company at Youngstown, Ohio, or to the Hydraulic Pressed Steel Company, Cleveland, Ohio.

* * *

The Erie City Iron Works, of Erie, Pa., has established a direct sales office at 1105 Leader Building, Cleveland, Ohio, with Eugene Smith, as district manager.

* * *

James T. Castle, Pittsburgh, Pa., has been given an order by the Union Barge Line Corporation for six standard turbo generator sets.

* * *

The H. K. Porter Company of Pittsburgh, Pa., announces the removal of their Chicago office from No. 447 Mondnock Building to the New Engineering Building, Wells Street and Wacker Drive.

Mr. George Kirtley, district manager of the Chicago office, remains in charge as heretofore.

* * *

The Grand Rapids, Mich., branch office of Allis-Chalmers Manufacturing Company, has been moved to 310 Building and Loan Building. This office is in charge of G. C. Culver, and is a branch of the Detroit office.

* * *

The Ohio Electric & Controller Company, Cleveland, Ohio, announce the appointment of the following representatives: Charles L. Ward Company, 701 Midland Building, Kansas City, Mo., covering the territory of Kansas City and the territory surrounding it, Omaha, Neb. and Dallas, Texas, and the territory adjacent thereto. J. Dale Reynolds, Apartado 428, Monterrey, N. L., Mexico, covering the country of Mexico.

NEWS OF THE PLANTS

The Scullin Steel Company has completed and placed in operation a new steel mill unit in which an entirely new variety of products will be manufactured. The addition has an annual capacity of 50,000 tons.

One of the units now being built will provide for the manufacture of railroad spikes, and another will provide for reinforcing concrete bars, and other products from rolled rails. The company's present structural steel mill, built 10 years ago, has a capacity in excess of 100,000 tons. It produces tie plates, structural steel shapes and similar commodities.

* * *

The construction of 15 additional Koppers-Becker by-product coke ovens at the Canton works of the Central Alloy Steel Corporation, where it now has 47 ovens in operation, will begin immediately, and it is expected the improvements will be completed and in operation in six or seven months.

Installation of a gas holder of 500,000 cu. ft. capacity and some necessary changes in the equipment of the by-product department also have been authorized.

* * *

The Jones & Laughlin Steel Corporation has acquired control of a merger of two Pittsburgh concerns, the Frick-Reid Supply Company, distributors of oil country pipe and oil well supplies and the Frick & Lindsay Company, which is engaged in the mill and mine supply business.

* * *

The Acme Steel Company, Chicago, has made plans to build a continuous billet heating furnace, producer-gas fired at the Riverdale, Ill. plant. This will be the third unit of the kind at this plant. Flinn & Drefflein Company, Chicago, are the contractors.

* * *

Agreements with the city council regarding assessments on the properties of the Canadian Steel Corporation at Ojibway, Ont., involve a steadily increasing program of employment. While somewhat less than 200 men are now employed at the plant at Ojibway a tentative arrangement providing a minimum of 500 men employed by the end of 1931 and 1000 men for the four years thereafter indicates the intention of the company to increase its activities at that place.

* * *

The formal opening of the B. & O. railroad line connecting the American Rolling Company's plant at Middletown, Ohio, with the Hamilton Coke & Iron Company at Coke Otto, north of Hamilton, Ohio, was set for June 25. On that date a trainload of hot metal was moved over the road with railroad and steel company officials and others participating in the ceremonies.

* * *

Several improvements have recently been completed at the Stalin Metallurgical plant in the Ukraine. Blast furnace No. 4 has been rebuilt and its capacity increased from 5,000 to 7,500 tons a month. A new building for the generators has been erected and a new elevator put up at a cost of 510,000 rubles. In the

Bessemer and machine departments much new equipment including pneumatic drop hammers, file making machines, lathes, etc., has been installed. A new foundry building has been completed and a 15-ton crane and two 6½-ton cupola furnaces with ventilators installed. The water requirements will be taken care of by a reservoir with a capacity of 208,000 meters recently completed and a second of 300,000 cu. meters which will be finished this year.

Last year the capital expenditures of the Stalin plant amounted to 5,000,000 rubles and this year the budget allotment is 5,300,000 rubles for new construction, equipment and capital repairs.

Power Show Date Announced

The Seventh National Exposition of Power and Mechanical Engineering will be held December 3 to 8, 1928 at the Grand Central Palace, New York City. The annual conventions of the American Society of Mechanical Engineers, and the American Society of Refrigerating Engineers will also be held in New York on this date.

COMING MEETINGS

Aug. 29-Sept. 2—Eleventh annual conference on Human Relations in Industry, at Silver Bay, Lake George, N. Y. Fred H. Rindge, executive secretary, 347 Madison Avenue, New York City.

* * *

Sept. 4-7—Canada's second steel and power show, University of Toronto Arena, Toronto, Ont. Campbell Bradshaw, executive director, 24 Front Street, West, Toronto.

* * *

Sept. 17-20—American Society of Mechanical Engineers, second national fuels meeting at Cleveland, Ohio. Calvin W. Rice, secretary, 29 W. Thirty-ninth Street, New York City.

* * *

Sept. 24-Oct. 6—World Power Conference, Fuel Conference at the Imperial Institute, London. The Secretaries, 36 Kingsway, London W. C. 2, England.

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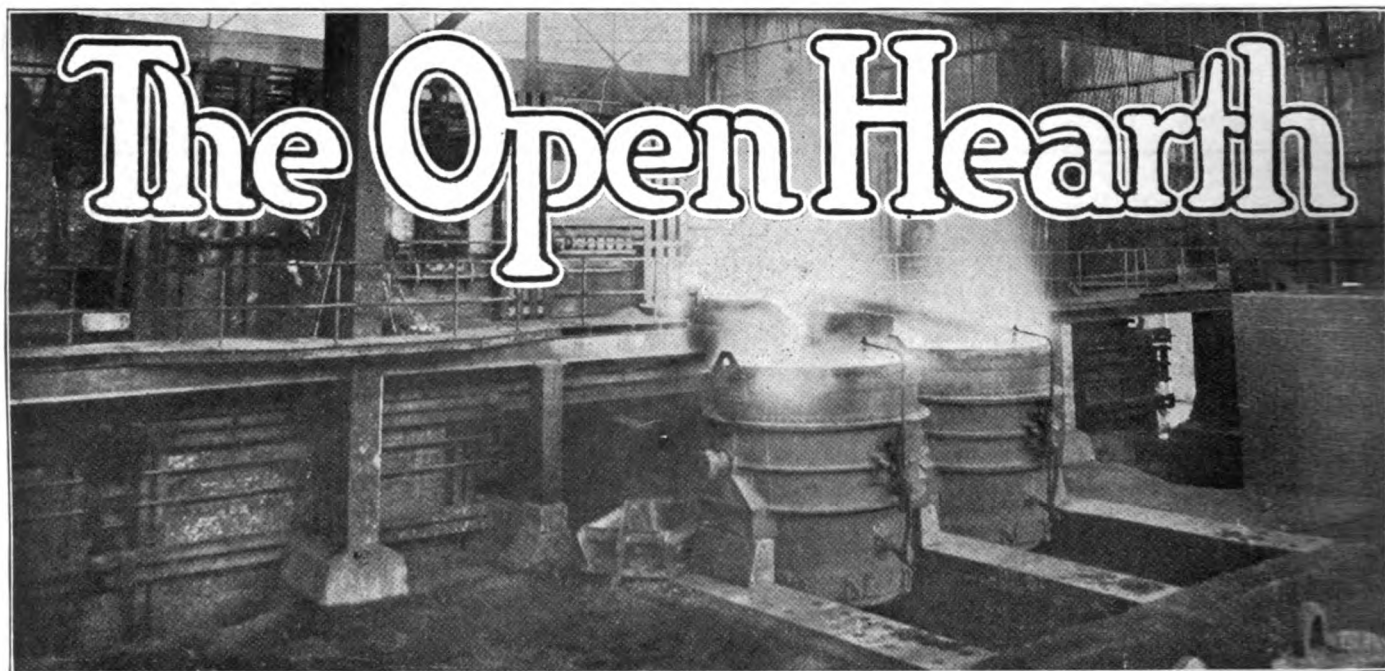
Oct. 1-5—National Safety Council, seventeenth annual safety congress at New York City. Idabelle Stevenson, executive secretary, 1 Park Avenue, New York City.

* * *

Oct. 8-12—American Society for Steel Treating, tenth annual convention and exposition at Philadelphia. W. H. Eisenman, secretary, 7016 Euclid Avenue, Cleveland, Ohio.

* * *

Oct. 11-13—American Gear Manufacturers' Association. Semi-annual meeting, Statler Hotel, Buffalo. T. W. Owen, secretary, 3608 Euclid Avenue, Cleveland.



Mr. James Cleary, whose appointment to the position of general sales manager of Combustion Engineering Corporation is announced, has been engaged in engineering and sales work for over 25 years. Mr. Cleary began his career as an erecting and operating engineer for the Westinghouse - Church - Kerr Company in which capacity he was sent abroad to place in operation the plants of the Metropolitan Railway Company, London, the Mersey Railway, Liverpool, and the Clyde Valley Electric Power Company, Glasgow. On returning to America he was employed by the Westinghouse Machine Company and at a later period by the Public Service Gas & Electric Company, New Jersey. Since joining the Combustion Engineering Corporation in 1921, Mr. Cleary has been district manager in Philadelphia and Detroit and for two years he served as assistant general sales manager. He was an officer in both the Spanish and World wars.



Robert A. Gillies, assistant superintendent of blast furnaces, South Chicago Works, Illinois Steel Company, since 1925, has resigned to become superintendent of the Steel Company of Canada, Ltd., Hamilton, Ont. Mr. Gillies began work at the South Chicago Works as a boy in the chemical laboratory.

F. G. Gasche has been appointed combustion engineer of the Bethlehem Steel Company's plant at Lackawanna, N. Y., succeeding E. E. Kiger who died recently.

A. F. Morris, vice president and sales manager for the last five years, has been elected to succeed the late Col. W. H. Morgan, as president of the Morgan Engineering Company. C. L. Taylor was re-elected

vice president; Charles H. Birr, chief engineer, secretary and comptroller; William J. Stoop, general manager, and T. D. Russell, treasurer; William H. Morgan, Jr., was elected a director; A. V. Cannon and R. A. Cannon, both of Cleveland, were re-elected directors.

* * *

J. K. B. Hare, recently manager of the Columbus, Ohio, office of the Westinghouse Electric & Mfg. Company, has been appointed assistant central station sales manager of that company. He will be associated with G. E. Wearn, central station sales manager, and will have his headquarters at the company's office at 150 Broadway, New York City.

* * *

A. B. Benson, formerly secretary and treasurer of the Conveyors Corporation of America, has been appointed general manager of the Joseph Harrington Company, a subsidiary of Whiting Corporation, Harvey, Ill. Mr. Benson's experience has been largely in the power plant field. His appointment will relieve Joseph Harrington, president of the Harrington Company who is well known as a combustion engineer and designer of stoker equipment.

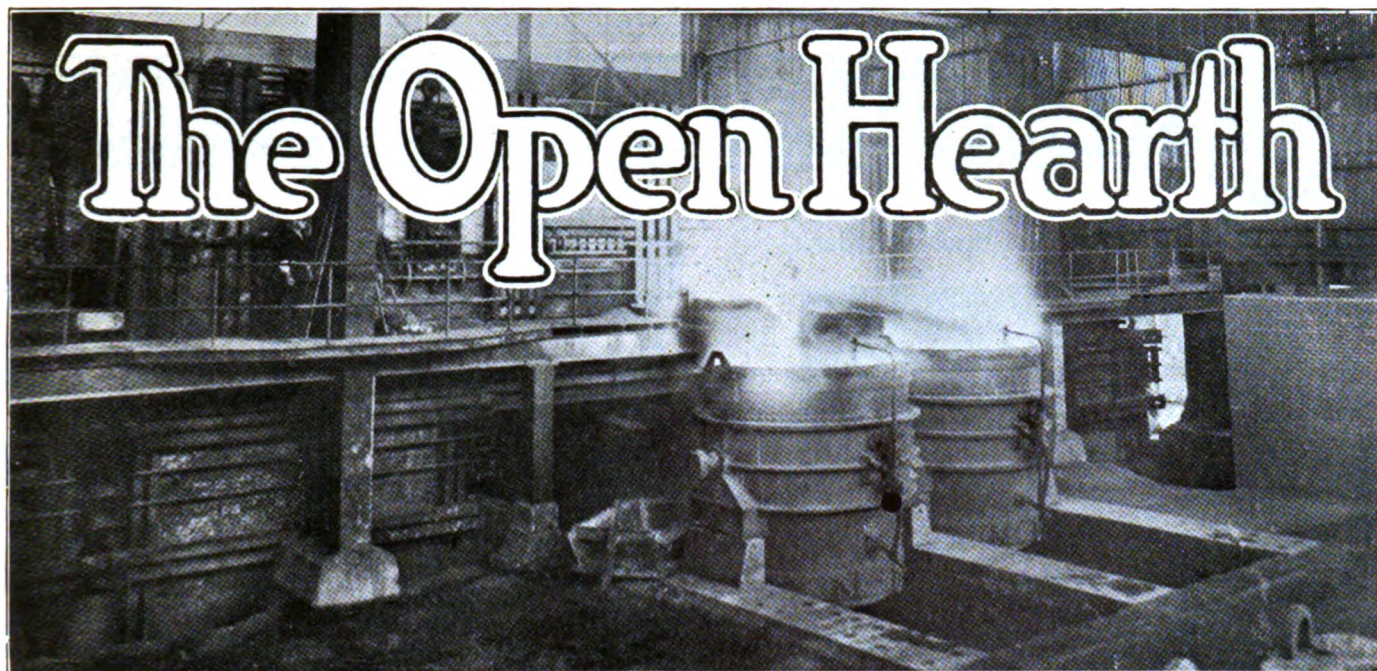
* * *

D. W. Wilson, has been elected vice president and general manager of the Dry Quenching Equipment Corporation.

Mr. Wilson has been intimately associated with the coke oven and gas industries for many years. He has been active in the work of the carbonization committee of the American Gas Association and has contributed various technical papers and articles relating to the subject of this committee's work. His previous identifications have been with the Wilputte Coke Oven Corporation and the Iroquois Gas Corporation. He was also assistant professor of chemical engineering at the Massachusetts Institute of Technology.

* * *

E. H. Weitzel, vice president of the Colorado Fuel & Iron Company, has resigned after about 21 years of service. His advice will still be available to the company.



Samuel A. Curry has been appointed superintendent of inspection and test at the South Philadelphia Works of the Westinghouse Electric & Mfg. Company. Mr. Curry who was field engineer and turbine test engineer, was appointed to fill the position made vacant by the recent accidental death of John T. Snyder.

* * *

F. H. Frankland, who has been supervising structural engineer, specializing in steel work, for Dwight P. Robinson & Company of New York, has been selected to head the engineering service bureau created by the American Institute of Steel Construction. This bureau will direct and co-ordinate the work of the 10 field engineers recently appointed by the institute.

Mr. Frankland has had extended experience. After attending Sheffield Scientific School of Yale University, he engaged in structural engineering work in New Zealand and Australia. Later returning to the United States, he engaged in designing bridges and industrial structures in California and Louisiana. He was for four years managing engineer for Waddell & Son, New York City, and later was general manager and chief engineer in charge of design, estimating and production for the Bancroft-Jones Corporation of Buffalo, N. Y.

* * *

Ralph Simpson has been appointed sales and service representative of the Geometric Tool Company, New Haven, Conn., for eastern New England territory.

* * *

N. H. Orr has been appointed contracting engineer for the junior beam division, steel construction department of the Jones & Laughlin Steel Corporation.

* * *

J. Ramsey Speer has resigned as president of the Mackintosh-Hemphill Company. Mr. Speer has been president of this company for five years, or since the merger of the Pittsburgh Iron & Steel Foundry Company, the A. Garrison Foundry Company, the Woodward Machine Company, and the Fort Pitt Foundry to form the present Mackintosh-Hemphill Company.

Mr. Fred Hughes Moyer is at present the head executive officer of the company. The Fort Pitt Foundry ceased operations on June 30 as the property was sold to the Pennsylvania Railroad for the purpose of expanding its freight yards.

* * *

Geo. Buckwell, for the past eight years in charge of the Pittsburgh office of the M. A. Hanna Company, Cleveland, resigned July 1 to take charge of sales of pig iron, coke and by-products for the Sharpsville Furnace Company, Sharpsville, Pa.

* * *

H. W. Graham has been made head of the metallurgical and inspection department of the Jones & Laughlin Steel Corporation, Pittsburgh, succeeding F. S. Slocum who retired July 1.

* * *

Walter C. Teagle, president of the Standard Oil Company of New Jersey, has accepted an invitation to become a member of the advisory board for the Second International Conference on Bituminous Coal to be held at the Carnegie Institute of Technology in the week of November 19, 1928.

Meeting of Blast Furnace and Coke Oven Association

Members of the Eastern States Blast Furnace and Coke Oven Association gathered on June 12 at the Edgewood Country Club, Pittsburgh, for the annual meeting and election of officers. Due to the absence of Mr. B. F. Fairless, Mr. E. A. Portz, general superintendent of the Central Alloy Steel Corporation read Mr. Fairless' paper, "The Importance of Coke and Pig Iron in the Production of Quality Steel." The following officers were elected for the ensuing year: President, B. W. Winship, superintendent of coke ovens, Bethlehem Steel Company, Steelton, Pa.; vice president, W. A. Haven, superintendent North Furnaces, Republic Iron & Steel Company, Youngstown, Ohio; secretary-treasurer, J. E. Lose, assistant general superintendent, Homestead Steel Works, Carnegie Steel Company, Murhall, Pa.



THE STEEL PLANT ROLL TURNER AND DESIGNER

Advanced to General Superintendent



C. A. McDOWELL

C. A. McDowell formerly roll designer for The Bourne Fuller Company, of Cleveland, has been advanced to the position of general superintendent of their Union Mill.

An Example of Roll Design for a Three-High Blooming Mill*

(Continued from last issue)

Third: The size of each roll is determined. As a preliminary step to finding the size of the rolls, the diameters of the middle and bottom rolls may be assumed to be the same as their pitches, $43\frac{1}{8}$ in. The pitch size for the middle and top roll is $40\frac{3}{4}$ in., and if from twice this pitch the diameter of the middle roll is subtracted, the pitch diameter of the top roll is the result, which in this case would be $35\frac{5}{8}$ in. If, now, the diameter of the working pass in the middle roll is subtracted from this diameter of the roll, the result is twice the depth of the groove.

$43\frac{1}{8}$ in. — $23\frac{3}{4}$ in. = $19\frac{3}{8}$ in. $19\frac{3}{8}$ in. $\div 2 = 9\text{--}11/16$ in. depth of first groove in middle roll.

Similarly, $38\frac{5}{8}$ in. — 24 = $14\frac{5}{8}$ in. $14\frac{5}{8}$ in. $\div 2 = 7\text{--}5/16$ in., depth of groove for the top roll.

The sum of these two quantities is 17 in. which checks with the size of second pass. But more of the piece lies in the middle than in the top roll, so in order to get the same height of collar, $8\frac{1}{2}$ in. in each roll, it is

*The Making, Shaping and Treating of Steel. Carnegie Steel Company.

necessary to increase the radius of the top roll and decrease the radius of the middle by $1\text{--}3/16$ in., making their respective diameters 41 in. and $40\frac{3}{4}$ in. The diameter of the bottom roll would then be $45\frac{1}{2}$ in. ($2 \times 43\frac{1}{8}$ in. — $40\frac{3}{4}$ in.). In order to get the proper clearance between the rolls, which is assumed to be 1 in., these diameters are further reduced to 40 in., the diameter of top roll; $39\frac{3}{4}$ in., the diameter of middle roll; and $44\frac{1}{2}$ in., the diameter of bottom roll. These diameters give a much deeper groove in the bottom roll than in the middle, which can be overcome by cutting down the collars on the bottom roll, which has the effect merely of increasing the clearance. So to balance up the depths of these grooves a clearance of 2 in. is allowed between these rolls, making the final diameter of the bottom roll $42\frac{1}{2}$ in. The finding of the depth of the remaining grooves is a simple manner. Thus, for example, No. 4 pass is $14\frac{3}{4} \times 17$ in. From the depth of the pass, $14\frac{3}{4}$ in., the clearance of 1 in. is subtracted, leaving $13\frac{3}{4}$ in. This depth is equally divided between the top and middle rolls, making $6\frac{7}{8}$ in. in each. It follows that the groove in the middle roll for No. 3 pass must be the same. As the depth of this pass is $17\frac{1}{4}$ in., the groove in the bottom roll must be $8\frac{3}{8}$ in., ($17\frac{1}{4}$ in. — $6\frac{7}{8}$ in. — 2 in. = $8\frac{3}{8}$ in.) To take care of variations due to wear in the rolls and permit of their being dressed, thus increasing their life, the entire set is made a little over-size in diameter of body, usually about three-fourths of an inch. They are discarded when they have been dressed down to the same amount undersize.

Behavior of Different Grades

J. R. Miller

It is hard to convince persons not familiar with the roll designer's problems that certain sections necessarily come out more satisfactorily in some grades than in others. Sections with deep flanges for instance do not fill up as well in open hearth as in Bessemer and certain of these are extremely hard to produce in high carbon open-hearth grades. Often a consumer is dissatisfied with the result, and cannot understand why he cannot obtain the same clear cut flanges that he is accustomed to get when Bessemer grades are specified.

This is particularly noticeable on the small deep flanged channels and on some of the special agricultural shapes which in times past were made exclusively of Bessemer. The principles involved apply to all shapes and due allowance is made in roll design and methods of rolling to accommodate these variations in the behavior of the steel.

By clever design of the rolls and manipulation in rolling some of the more difficult sections may be rolled in the adverse grades to a passable degree of accuracy; however, variations in the carbon incident to high carbon open-hearth grades are apt to render the result variable. In these instances it is more satisfactory to use Bessemer which for the required stiffness runs some 15 points lower in carbon and also by its nature rolls better in similar carbons.



THE STEEL PLANT BRICK MASON

Papers on Refractories

Among the papers listed for presentation at the annual meeting of the American Society for Testing Materials, held at Atlantic City, June 29, two pertained especially to steel furnace refractories.

The report of Committee C-8 on Refractories, G. A. Bole, chairman:

Recommends for adoption as standard the specifications for clay fire brick for malleable furnaces and annealing ovens, for stationary boiler service and for marine boiler service; and the tentative definitions relating to refractories. It submits a survey of the use of high-temperature cements in boilers; a study of the hot abrasion test on refractories; a study of variations in P.C.E. value of refractory cements containing sodium silicate.

The second paper bears the title, *Methods for Measuring Thermal Conductivity of Insulating and Refractory Materials*. M. L. Hartmann and O. B. Westmont.

It describes a testing apparatus and methods of determining the thermal conductivity of (1) low-temperature insulating materials, (2) insulation for temperatures up to approximately 2,400 deg. F. and (3) refractory materials. A standard test method is proposed.

Heuer in Philadelphia

Dr. R. P. Heuer, recently appointed director of research for the General Refractories Company, will make his headquarters at the general offices of the company in Philadelphia.

New Refractory Plant

The Missouri Insulating & Refractories Company, St. Louis, Mo., recently organized by Mr. Frederick E. Kern and associates, has plans for a plant for the manufacture of fire brick and refractory shapes, as well as other insulating products suitable for blast furnace linings and for other high refractory service. A site has been acquired on Clayton Road, and work is expected to begin at an early date.

Sieber Promoted

David R. Sieber, for the past five years Pittsburgh district manager of sales for the General Refractories Company, Philadelphia, Pa., has been elected a vice-president of that company. Mr. Sieber joined the General Refractories Company in 1922 when that company absorbed the Standard Refractories Company with which he had been connected since 1917.

Refractories and the Chemist

In the course of his address at the Chemical Industry Conference, Sir Arthur Duckham called attention to the need for satisfactory refractory materials with good jointing and patching cements to meet all reasonable temperature conditions, and to resist the chemical action arising internally in the carbonizing vessel. He put this as a problem for the chemical engineer. The construction of kilns, the mechanism for the even burning of the refractories, the methods of grinding the ingredients, may be chemical engineering problems, but it is the chemist who is at the heart of the matter, namely, the diagnosis of the faults and the discovery of improvements in composition.

It is certain that at the present time this subject of refractory materials is exercising the minds of those responsible for the operation of carbonizing plants working at high temperatures more than any other problem. Although there have been marked improvements during the past few years, much remains to be done. The use of high grade silica as a material in the construction of carbonizing plants has led to greatly improved results in the production of gas—bigger outputs per square foot of ground space and higher yields of gas per ton of coal treated. The demand for silica material has consequently greatly increased, and

it is due to the application of fundamental chemical science to the requirements that it has been possible to supply industry with its needs. Rule of thumb methods are of little avail in the production of this material of such even quality that it will withstand the stringent standard tests laid down for refractory materials. The manufacturer has therefore called in the services of the chemist. The examination of refractoriness, specific gravity and expansion, the study of structure by means of microscope and macro-section, have been the chemist's tools in determining the requirements for the successful production of high-grade refractory materials. —Chemistry and Industry.

Thermal Expansion of Brick

Announcement is made by the U. S. Bureau of Standards of the results of a comprehensive study of the fundamental qualities of fire-clay refractories and individual clays. In its report the bureau says:



Frank L. Mountain, superintends brick work at the Alan Wood Iron & Steel Company. Evidently he inherited his liking for the steel mill.

* * * * *

THE STEEL PLANT BRICK MASON

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"The linear thermal expansion has been observed from room temperature to 900 deg. C. by means of the interferometer on a total of 21 clays burned at 1400 deg. C. for five hours. These are the clays used in the manufacture of the 17 brands of fire brick included in this investigation. The clays may be classified according to the thermal expansion into four groups, as follows.

"1—Eleven have a rapid rate below 200 deg. C., due to the presence of tridymite and cristobalite, and a uniform rate from 200 to 900 deg. C.

"2—Three have rapid rates of expansion below 200 deg. C. and at approximately 600 deg. C., due to presence of the different types of silica.

"3—Nine have a uniform rate from room temperature to 900 deg. C.

"4—Two have a uniform rate from room temperature to approximately 725 deg. C., at which temperature the rate increased until 850 deg. C. was reached, after which it decreased.

"In comparing these data with those obtained on the brick in which the clays were used either singly or blended and which were previously reported it was noted that—

"1—In four instances the rapid rate of expansion below 200 deg. C. shown by the clays was not apparent in the bricks. It is possible that this difference is due to the blending of two or more clays which is favorable to the growth of mullite crystals at 1400 deg. C.

"2—Two brands of fire bricks show a rapid rate of expansion at 600 deg. C., which is not present in the individual clays. This expansion in the bricks is undoubtedly due to the nature of the grog added in the manufacturing process.

"3—In two cases where bricks are manufactured from the same clay by both the stiff-mud and dry-press methods the expansion of the clay is higher than that observed on the brick of either type."

—The Clay-Worker.

Effect of Insulation on Open Hearth Furnaces and Soaking Pits

By Walter T. Kennedy*

It is generally acknowledged by steel plant and fuel engineers that parts of these furnaces can be insulated to very good advantage, the limiting factor being the ability of refractories to give a satisfactory life under the conditions to which they are subjected.

It is now general practice to insulate around the checker chambers, flues, and boilers; also a number of furnaces have been insulated around the slag pockets up to the charging floor level; also around stack bases to protect the concrete from calcining and cracking.

With the exception of one small acid furnace, all new open-hearth furnaces and a number of pits built in the United States in 1927, as listed by one of the leading trade papers, were insulated and some 70 open hearths and pits have been built or being built by more than 20 of the leading steel companies which are insulated with Sil-O-Cel materials, and in all cases

*Steel plant representative, Celite Products Company.

the results have been completely satisfactory. By the usual method of application this insulation reduces the radiation losses from 60 to 75 per cent retaining this heat for useful work in the furnace; also it prevents air infiltration due to the microscopic entrapped air cells. A Sil-O-Cel standard brick is impervious to air penetration at a pressure as high as 1 lb. per sq. in.; also by reducing the outside temperatures of the heated surfaces, steel jackets are practical, which protect the walls and give added protection against air infiltration. In case steel jackets are not desirable due to the difficulty of locating gas leaks, insulating brick are bonded between fire brick and red brick.

The results obtained through insulating are higher preheated air and gas temperatures, also higher temperatures to the boiler, faster, sharper working furnace, direct saving of fuel, high heat storage capacity during shut down over week-ends, prevention of brick spalling from too quick changes in temperature due to sucking cold air, (especially with silica fantails); also eliminating the tendency for checker side walls to belly in, due to the fact that insulation gives a more even heat gradient and uniform expansion through the brick work.

Fig. 1 shows a standard specification for insulation in open hearth chambers and flues and Fig. 2 shows an insulated soaking pit. The insulation in the side walls and over the arches is very effective.

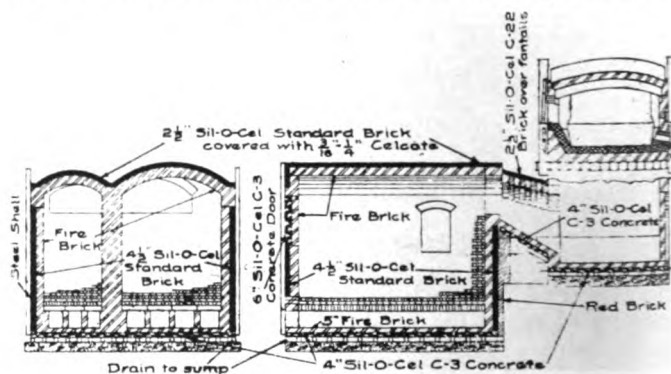


FIG. 1

However, in some instances, insulation in the bottoms of chambers and flues has been questioned. When proper consideration is given it is seen that this application is important. The conduction of heat into the bottoms and surrounding ground is very high and also in most cases open hearth chambers have been built in the wettest places obtainable and the constant evaporation of water is a heavy drag on the furnace, as well as controlling the temperature in the bottoms of the flues and chambers. Insulation will also prevent calcining and breaking of the ordinary concrete mats under the chambers and flues. Sil-O-Cel C-3 concrete, is very strong mechanically, has good insulating value, is cheaper to install than its equivalent of firebrick, a thinner bottom can be used and in one case allowed the same checker chamber volume keeping the bottoms of the chambers 6 in. nearer ground level than had been figured on for a fire brick bottom. This concrete will not deteriorate in moisture.

THE STEEL PLANT BRICK MASON

The theoretical savings which may be made need not be discussed here as the steel plant operator is interested mostly in proven dollar and cents savings per ton of steel and time gained in open hearth is dollars and cents, just as much as reduction is fuel. There is, of course, another feature which enters that the life of the brickwork is satisfactory. A number of furnaces have been insulated over the arches of the chambers, which is the thinnest and hottest section, for 10 years and while the life of a set of chambers should be twice this, there has been no indication that the insulation has any effect upon the life of the refractories.

One of the best open hearth superintendents in Pittsburgh district revamped some old furnaces which were in a line with identical furnaces. These furnaces melted steel on an average of 50 min. faster per heat than the uninsulated furnaces, and the salvage of

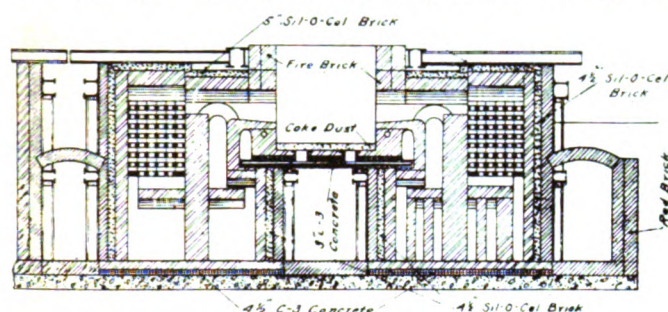


FIG. 2

checkers was considerably higher from the insulated chambers than the uninsulated ones. This is attributed to the fact that a short, sharper working flame brought the boil nearer the incoming ports and allowed more oxides to settle on the bath rather than being carried over into the chambers.

Temperatures were taken at various corresponding points on insulated and uninsulated chamber walls. At one of the middle western plants the uninsulated chamber walls showed a temperature average of 336 deg. F. and the insulated 191 deg. F. or a difference of 175 deg. F. The arch temperatures were not taken, but would have shown a much greater difference in temperature. The insulated furnaces are 500 tons per month better than the uninsulated and they are now insulating the old furnaces as repairs are made.

In the Cleveland district an open hearth plant was run with fuel meters on the furnaces for four months. An insulated furnace which is identical to the other furnaces, with the exception that insulating brick was used to displace a course of fire brick and also was used over the arches. The insulated furnace showed 8 per cent better efficiency over the average of the uninsulated furnaces. The insulated furnace and one of the uninsulated furnaces were comparable as they had been operating about the same length of time. By comparison the insulated furnace produced 553 more tons per month on 110 millions of Btus. less fuel than the uninsulated. A plant in the St. Louis district has reported an average increased efficiency of 7 per cent by insulating the chambers,

The furnace designed by Mr. Stevens, a consulting engineer of Chicago, and built at American Steel Foundry, Indiana Harbor, is insulated in the bottoms, side walls and over the arches, also the slag pockets and is reported as having a very low melting cost per ton. This furnace, of course, has a number of new features included in its design and it is not the intention to claim too much credit for insulation, but rather to give the impression that included with other improvements makes a good combination, which returns the investment quickly and continues to make money over a long period.

Recently the chambers of an open hearth were insulated by placing a 4 in. thick reinforced and tied in wall of insulating concrete around the chambers applied with a cement gun. While there are no figures available yet as to results obtained the application should be very satisfactory as it is of monolithic construction, giving excellent air-proofing qualities, as well as good insulating value and was surprisingly low in cost to apply. It does not require a steel jacket which is high in cost and difficult to make a good job on old chambers.

Mining Problems of Red Iron Ore District, Alabama

Modifications of current mining practice and certain radical changes in virtually all methods of working the red iron ore mines of the Birmingham district, Ala., probably will be required, the United States Bureau of Mines points out following a study of the development, mining, and handling of ore in folded and faulted areas in this district. These changes will be necessary because of the increasing depth of cover and the necessity of more adequate support, the larger amounts of water that must be pumped from the mines, and the need of extracting a higher proportion of the ore. The possibility of utilizing the low-grade high-silica ores that may be rendered available through beneficiation may help to bring about changes in practice, the bureau also suggests.

A report recently issued by the bureau, deals specifically with the development and handling of ore as affected by folds and faults in the ore bed, and considers changes that may be desirable or necessary in future mining practice.

Copies of this report, Bureau of Mines Technical Paper 407, "Development, Mining and Handling of Ore in Folded and Faulted Area, Red Iron Ore Mines, Birmingham District, Ala.," by Dr. W. R. Crane, may be obtained from the superintendent of documents, Government Printing Office, Washington, D. C., at a price of 15 cents.

Make Good Joints

First, use the same care in selecting your mortar or cement as in selecting the brick themselves; second, make tight, brick-to-brick joints; third, thoroughly dry the furnace before putting it in regular service. Joints should be just as good as the brick.



SAFETY FIRST IN THE STEEL PLANT

Urge Early Hotel Reservations for National Safety Congress

Those who are planning to attend the Seventeenth Annual Safety Congress, to be held in New York City, October 1-5, are advised to make early reservations for hotel accommodations. Requests for room reservations may be sent direct to the New York office of the National Safety Council, Room 402, 21 East Fortieth Street, or to the headquarters of the council in Chicago.

High Cost of Infected Injuries

Over 13 per cent of all injuries caused by industrial accidents in New York State became infected during the fiscal year ended June 30, 1927, according to a recent report of the New York State Department of Labor. The cost of infected cases was twice that of non-infected cases, the former averaging \$188 as compared to \$93 for the latter.

—Metropolitan Life Ins. Co.

Accident Prevention Activities at Joliet Works

The month of November, 1928, will mark the thirty-sixth anniversary of the birth of industrial accident prevention, and it is with pride we announce the many safety records made by Joliet Works organization in addition to the honor of being the originators of this worthy cause. Since the issuing of the first safety order it was found that the correction of dangerous conditions and practices in safeguarding affected the co-operation and interest among the employes making possible the elimination of many serious accidents. The elimination of accidents is not an easy task. From the time of the first start new problems and hazards were experienced, making progress slow and discouraging. It was found that the correction of dangerous conditions by the installation of safety devices on machinery alone did not eliminate all preventable accidents and to obtain greater co-operation of every workman, an educational campaign, in addition to the safeguarding of machinery must be instituted. An intensive educational campaign was therefore inaugurated in each department teaching the fundamental principles of safety.

—The Mixer.

Safety Recommendations

The Department of Labor and Industry of Pennsylvania has distributed throughout the state a small booklet bearing the title "Safe Practices Recommendations." The special foreword in this booklet states:

These safe practices recommendations have been developed and promulgated by the Department of Labor and Industry for circulation among employers and workers in the State of Pennsylvania.

They should be carefully read and their provisions lived up to in detail if we are to make any considerable gain in accident reduction in our industries.

While most of the recommendations herein set forth are merely common sense, nevertheless, the accident records of Pennsylvania indicate that it is only through the constant exercise of common sense that material reduction of industrial accidents will be secured. The following statistics of causes of accidents reported during the year 1925 explain the necessity for observance of these recommendations.

Total accidents reported (causing absence from work of two days or more) were: Non-fatal, 174,370; fatal, 2,009.

The leading causes of these accidents were:

	Non-fatal	Fatal
Handling objects	34,560	57
Cars and engines (including slipping and falling under them)...	20,392	392
Fall of persons.....	17,813	204
Machinery	17,057	73
Hand tools	16,259	20
Falling objects in mines.....	12,253	412

Abuse of Guards

Engineers have designed and installed guards to offer protection against almost every conceivable hazard associated with machinery, and yet mechanical devices cause a large number of accidents. This is due in no small measure to the fact that workmen remove guards to make adjustments and repairs and either forget to replace them or wilfully neglect to do so; or they remove guards in the belief that they interfere with the work.

—The Youngstown Sheet & Tube Bulletin.



With the Midvale Company, John B. Mudd is safety engineer; with the National Safety Council, he is a member of the executive committee.